TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE
IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. XIV, No. 6. JUNE, 1937. PRICE 6d.

CONTENTS.

	PAGE.
Efficient Cacao Production	161
Tropical Fruits and Vegetables. An account of their Storage and Transport	163
Observations on the Pupal Diapause of the Orange Dog (*Papilio Anchisiades* L.)	170
The Cacao Industry of Trinidad	172
Lepidopterous pests of the Sour-Sop in Trinidad	175
Effect of Artificial Manures on Crop Quality	178
Recent Investigations on Sugar Cane and Sugar Cane Soils in Antigua	179
Reviews	188
Sugar Notes	190
Efficient Rat Trap	190
Chemical Notes	191
Trend of the Markets	192

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 2183

TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C.3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

EFFICIENT CACAO PRODUCTION.

WE conclude in this issue Professor Shephard's series of articles presenting the analyses of records of a large number of Trinidad cacao estates. As a result of this survey various popular conceptions regarding the economic organisation and financial condition of the Trinidad cacao industry have been proved erroneous while some of the more important factors associated with profitable and unprofitable estates have been ascertained. For example, the average yield of cacao in the Colony has been shown to be considerably lower than was generally believed while the average cost of production of the crop has been found to be actually much higher than the popular estimate. The analysis of the records has shown that high yields, low expenditure on cultivation, specialisation in the production of cacao, youthful fields and medium-sized estates were all found to be associated with low costs of production. Recommendations, however, cannot be based with safety on these findings because the relations are not always those of cause and effect. On the other hand the survey has been of greatest value in suggesting that certain factors play a particularly important part in the comparative success or failure of an estate. Of these factors, soil type and age were believed to be of exceptional importance and were accordingly studied in detail. The results of this investigation, together with recommendations for the rehabilitation of Trinidad cacao estates, have just been published in a separate paper* which forms a sequel to the series of articles concluded in this number of the Journal. We believe that this paper will provide planters with information likely to throw some new light on their problems and because of this we feel that it will be well worth a close study.

The most serious problem of the Trinidad cacao industry is the heavy and continuous decline in the exports of cacao which has taken place since 1921. This is a matter of grave concern to Government and to all directly or indirectly interested in the industry. The downward trends in the Colony's production and of individual estates has to a certain extent been explained by reductions in acreage and the neglect of cultivation necessitated by low cacao prices, but the records of individual fields have shown that part of the decline must also be attributed to factors associated with increasing age. Examination of the yields of individual fields has revealed a rising

* C. Y. Shephard. The Cacao Industry of Trinidad. Some Economic Aspects. Series III.—An Examination of the Effects of Soil Type and Age in Yield. Series IV.—Recommendations for Improving the Efficiency of Estates. Price 4s. 6d. Post free.

trend to a peak which is reached in 15 to 25 years, and a falling trend in subsequent years. The fact that most cacao fields in Trinidad are over 25 years of age may thus account for part of the fall in the Island's exports of cacao. Soil type, however, governs the magnitude of the peak-field and the rate of deterioration to an unprofitable level. Whereas falling field yields are primarily due to accumulating casualties among high-yielding cacao trees, the rate of decline is accelerated on some soil types by deterioration in the yields of the surviving trees, and retarded on other soil types by increases in the yields of the surviving trees. On some soil types most of the casualties among cacao trees are caused by irremediable soil defects and declines in yields appear inevitable because it is unlikely that there will be any available methods of controlling this tendency. On other types of soil the principal casualty factors such as falling shade trees are not related to defects of soil and affect only the cacao trees, so that yields may be restored by the use of selected plant material.

A striking feature of every field examined is the large percentage of poor bearing trees. On the poorer soils as many as 60 to 90 per cent. of the pickets do not yield more than one lb. of cacao each. Thus it is not surprising to find that estates situated on such soils incurred losses. On the better soils, where profits are earned, there is still room for considerable improvement because no less than 30 and in some cases as many as 50 per cent. of the pickets are cultivated at a loss! These figures reveal a surprisingly wide scope for raising the standard of production to a more efficient level. There can be no doubt that there are many estates where the greater portions of the fields are being cultivated at a loss thus masking the real profits on the better parts. It has been found that casualty factors are largely responsible for raising the percentage of poor bearing trees. Among these have been included fallen shade trees, insect pests, diseases, drought, landslides, blanks, dead trees and young supplies not yet bearing. In addition there are a few trees on good soils, and many on defective soils which fail to bear despite the absence of injury or any other obvious explanatory or extenuating factors. This is a problem on which extensive studies have been made and are still being conducted by the botanical section of the Cacao Research Scheme. The most important result so far has been to demonstrate among Trinidad cacao trees the frequent occurrence of self-incompatibility, or failure to set fruit on self-pollination.

It will be seen that the alarming decline in the production of cacao in Trinidad is due to various causes hitherto unrecognised but which have been brought to light as a result of the careful field investigations of the College Department of Economics working in co-operation with the Departments of Chemistry and Botany of the College. The age of the fields is undoubtedly one of the most important factors and perhaps it is significant that similar problems have arisen in the older rubber fields of Malaya which are said to have ceased to yield a profit. Some of the rubber companies have already taken measures to control this tendency by replanting and regeneration. In Trinidad it is evident that this problem will not be solved by the mere resumption of the traditional methods of cultivation. Dazzling prosperity has blinded Trinidad cacao planters to the defects in the organisation, and the steady deterioration in the efficiency, of their estates while the depression that followed has left them without sense of direction. It is quite evident that the whole organisation and methods of working estates must be reviewed in the light of our present day scientific and economic knowledge in order to raise their efficiency to new heights. Professor Shephard suggests in this connection that as a first step, financial stability might be secured by vesting the ownership of estates in companies instead of private individuals. This in itself would mean considerable changes in the present structure of the industry as a whole but would certainly offer various advantages. For the estates themselves he has drawn up a programme of rehabilitation which consists primarily in the elimination of areas incapable of earning profits and the intensive cultivation of the remaining areas including, more particularly, the replacement of poor-yielding mature trees by selected plants. Until more knowledge is acquired of planting material of known performance the safest method would be to replant with selected seedlings or vegetatively propagated plants from known parents. On some estates where this has already been done the growth of the young supplies suggests that the efficiency of rehabilitated fields on good soil will eventually be raised above their previous best. This in itself is an encouraging sign and it is to be hoped that more estates will see their way to make experiments on these lines as by doing so the future of the industry may in some measure be safeguarded.

The application of the results of this investigation is not confined to this island. In West Africa and Brazil most of the farms and estates are much younger than in Trinidad and their youth probably accounts in part for the large yields which are being obtained and which, in West Africa, are at least twice as large as those obtained in Trinidad. It has been suggested that yields in Trinidad were at one time higher than they are now. Thus, it seems probable that with increasing age yields will decline in the West African and Brazilian cacao fields and although exports may be maintained, or even increased for many years by planting new areas, a time must come when the possibilities of expansion have been exhausted. This is an eventuality for which these newer cacao countries will have to be prepared, and we believe therefore that the results of the investigation which we have reviewed here, will be of considerable interest to them.

TROPICAL FRUITS AND VEGETABLES. AN ACCOUNT OF THEIR STORAGE AND TRANSPORT.

By. C. W. Wardlaw.
Low Temperature Research Station.

(*Continued from Tropical Agriculture*, XIV, 5, 1937).

CITRUS.

Oranges.

A considerable temperature range is cited for the cold storage of oranges. This is indicated in the following notes :—

United States.—34°F. for periods of 1 to 2 months ; more prolonged storage productive of profuse pitting and the development of large, brown, slightly sunken spots at the stem-end (86) ; 32°F. also cited as a suitable storage temperature (86) ; for California oranges Fawcett (44) advises 38° to 40°F., with the proviso that it may be necessary to reduce the temperature to 32°F.-40°F. to combat stem-end rot ; for Valencia oranges grown in Texas, Friend and Bach (49) quote a temperature of 32°F. as giving satisfactory storage up to 20 weeks ; more recently for Texas-grown Valencia oranges Friend (48) advocates a temperature of 50°F. to eliminate browning of the rind ; under favourable conditions the fruit could be held for 90 days or longer ; for the overseas transport of California oranges Overholser (34) indicates a temperature of 36° to 38°F. ; at lower temperatures brown spotting of the rind may result ; for long storage of Florida oranges—up to 4 months—Camp and Stahl (23) found a temperature of 37.5°F. to be optimal provided pitting injury, due to chilling, was controlled by the application of a suitable wax and the use of water-proof wrappers and box-liners to achieve maximum moisture conservation.

South Africa.—For Rhodesian oranges, Bates (15) cites 40°F. as the most suitable storage temperature, 36°F. being safe for some varieties but conducive to chilling in most ; mid-season varieties remained in good condition in cold storage for periods up to 10 weeks.

Australia.—For Australian Valencia oranges, storage trials at 31°, 34°, 37°, 40° and 43°F. indicate that temperatures below 40°F. are productive of an undesirable brown blemishing (42) ; the storage life at 40° and 43°F. was terminated by loss of flavour after periods of 12 to 18 weeks for fruits from different localities ; as a result of storage trials at 34°, 36°, 38° and 40°F. with Valencia Late oranges grown in Australia, Tindale (98) considers a temperature of 37°F. as most suitable ; chilling injury was observed in fruits held at 34°F. but not at 36°F. after 4 months in storage ; Washington Navel oranges, stored at temperatures between 32°F. and 40°F. showed blemishing and breakdown at 32° and 34°F. ; at 36°F. fruit could be held in good condition up to 3 months (99) ; for Valencia and Washington Navel oranges Adams (1) considers 34°F. most suitable ; Navel oranges, according to Young and Read (113), kept best at a temperature of 45°F. ; at 32°F. after 5 to 6 weeks fruits acquired a bitter flavour ; after 11 weeks this became much more marked and fruits showed a collapsed appearance, the skin being dull and discoloured ; a similar condition occurred at 38°F. but the first appearance of collapse was observed later, after about 12 weeks. At 45°F. none of these chilling symptoms appeared during a storage period of 15 weeks, when the flavour was still normal and total wastage only 5 to 6 per cent. ; for Valencias the optimum temperature was 38°F. ; at 45°F. losses due to Alternaria and skin browning were greater (113) ; in an experimental shipment of Navel oranges from Australia to Canada, in unventilated holds designed for frozen meat and maintained at 38° to 40°F., with a transport period of 65 days, Young and Read (114) have reported wastage varying from 4 per cent. after some treatments as compared with 79 per cent. wastage after others ; fruit from different districts showed great differences in keeping quality ; in general the fruit, after this long voyage, was lacking in flavour as compared with Californian fruit ; rapid breakdown followed removal of fruits from the holds ; the lack of flavour and ability to hold up when removed from the ship, suggest that a voyage of 9 weeks is too long ; local experience also indicated that the storage of Navel oranges for longer than 7 to 8 weeks is rarely practicable ; a recent report (5) indicates the following temperatures as optimal for New South Wales fruit : 1st picking, 50°F. ; 2nd picking, 45°F. ; 3rd picking, 40°F. ; in general, 40°F. was too low, being productive of pitting (storage spot) ; at 50°F. the palatability of the juice and the texture and colour of the rind were markedly improved ; Valencia oranges gave good results at 37°F. and 45°F., although, at the lower temperature, fruits were not free from spotting.

Brazil.—For the transport and storage of oranges and citrus fruits from Brazil, Camargo (21) advises a temperature of 36°F. (2.2°C.) ; if picked when quite mature a storage life of 3 months may be anticipated.

West Indies.—For Trinidad oranges the following temperatures are advised : Cocoa, Valencia (63), Jaffa, Pineapple, Navel, Lamb's Summer (104a), 45°F. ; King and Satsuma, 40°F. (63).

Grapefruit.

A considerable temperature range is also given for the storage of this commodity.

United States.—Storage for longer than 10 weeks at 50°F. or lower temperatures, or at too low a humidity, may be accompanied by pitting (chilling) or rotting, especially if the fruit has been injured during picking or packing ; if stored at 50°F. or

higher, pitting may be avoided, but the flavour deteriorates more rapidly and decay is greater (86); for Californian grapefruit, Fawcett (44) cites 50° to 55°F. as the most suitable storage temperature. Poole (77) also advocates a temperature range of 50° to 55°F. for Florida and California fruit; in investigations with Texas grapefruit, Friend and Bach (49) found that a temperature of 45°F., giving storage up to 8 to 10 weeks, was more satisfactory than were lower temperatures, *e.g.*, 31° to 32°F.; some advantage was to be gained in storing late season fruit, slightly past its prime, at the lower temperatures, a storage life of 4 to 6 weeks being cited.

Recently Friend (48) has advocated a temperature of 50°F. as more suitable, pitting being avoided and green mould insignificant in amount. If fruit is held for 10 days at atmospheric temperatures, the subsequent development of pitting even at 31° to 32°F. is greatly curtailed. The length of time during which grapefruit can be successfully held in cold storage is from 60 to 90 days. For long storage of Florida grapefruit, Camp and Stahl (23) found a temperature of 37.5°F. to be optimal provided pitting, due to chilling, was controlled by the application of a suitable wax and the use of water-proof wrappers and box liners to achieve maximum conservation of moisture.

Allen and Pentzer (3) consider that optimal storage conditions for grapefruit comprise a temperature of 52° to 58°F. and R.H. of 90 per cent.

The relatively high storage temperatures advocated in recent or current publications should be compared with earlier recommendations. Thus in 1926 Hawkins and Barger (57) considered a temperature of 32°F. suitable for Florida grapefruit and many similar recommendations could be quoted. These earlier temperature citations are now invalidated by the accumulation of data on chilling injury.

Australia.—Reporting on Australian grapefruit, Williams (106) states that fruit should first be precooled at 50°F. and then placed in storage rooms at 35°F.; at this temperature with a R.H. of 80 per cent. fruit kept satisfactorily for 4 months; at 40°F. fruits became spotted, whereas at 35°F. little spotting occurred; fruit stored at 33°F. was also relatively free from spots. These results are at variance with the results of more recent storage tests with grapefruit in America and elsewhere. The probability is that a form of chilling other than pitting has been sustained or that pitting has been masked at 33°F. and 35°F.; this would become apparent in the speedy breakdown of fruit on removal from cold storage. In the experiments described by Williams, however, the fruit on removal from 35°F. was only held for a few days at 50°F. prior to being consumed. A recent Australian report (5) indicates a storage temperature of 45° to 50°F. as being optimal; at lower temperatures pitting was in evidence, and was not reduced by preliminary wilting treatment.

West Indies.—For Trinidad grapefruit, 45°F. has been found suitable for storage up to 50 to 60 days with the proviso that a higher temperature may be desirable for more prolonged storage (63, 64).

Chilling.

Chilling in grapefruit and oranges usually takes the form of a superficial blemishing which has been described and termed "pitting" (15, 49, 63, 64), "scald" (49), "storage spots" or "pox" (44, 71). In the literature some confusion exists with regard to this type of blemishing owing to the fact that several complicating factors have usually been present in the storage trials. It has now been shown that the initiation of typical pitting is due to injury to areas of superficial tissue—the parenchyma between the oil vesicles—as the result of exposure to low temperatures. Such injury, being quickly followed by desiccation of the tissues, gives rise to the typical pitted appearance. But as blemishing in general in citrus is a complicated phenomenon, attributable to many causes, typical chilling has been confused at one time or another with, or accentuated by, desiccation, oleocellosis, ethylene or borax injury.

When chilling is produced experimentally in grapefruit stored at a high relative humidity, the first symptom consists in the development over the surface of the fruit of shallow, saucer-shaped depressions, involving all tissues, and up to 1 cm. in diameter. At first there is no discolouration and no obvious softening of the sunken tissue. The peripheries of the blemishes become pink and finally the whole area turns brown (63, 64). When transpiration is allowed to proceed as in the normal storage room atmosphere, *i.e.*, where loss in moisture tends to be accelerated by lower humidities, similar superficial blemishes appear, but quickly become discoloured. Slightly different symptoms may occur in waxed, wrapped and crated fruit exposed to considerable desiccation, in the form of small, brown sunken areas between the oil vesicles; these spread and later involve the whole of the flavedo producing brown, sunken spots.

According to Bates (15) pitting in oranges is distinct from most other skin markings, although in the early stages it may bear some resemblance to oleocellosis injury:

> "The earliest symptom is a light-brown discolouration of the tissues surrounding the oil vesicles; usually only a small area is affected. A number of small irregular spots generally appear about the same time and may either be scattered over the fruit or be confined to a localised area. At this stage the oil vesicles included in the discoloured regions appear darker than normal. The markings gradually increase in size, and, where they are close together, frequently coalesce to form large and irregular lesions. In older lesions the tissues between the oil vesicles are depressed so that the vesicles stand up prominently giving a "pin-head" effect. At this stage the marginal outline of the vesicles usually

appears much darker than the centre. The lesions usually darken with age but do not always assume the same final colour, which may be various shades of brown. This gradual colour change is probably associated with the slow desiccation of the skin. For instance, when oranges showing pitting are transferred to higher temperatures the darkening is comparatively rapid. As the surrounding tissues dry out the oil vesicles collapse and finally appear as minute cavities. At first the lesions are superficial and do not extend below the flavedo. With long storage they gradually encroach into the underlying spongy albedo. There was, however, a pronounced varietal effect regarding the final degree of injury. Jaffa oranges not only showed more pitting than Valencias, but in the later stages the lesions closely resembled the scald of Friend and Bach (49). The entire skin below the lesions was affected in old Jaffa lesions. Valencias, on the other hand, were more resistant to severe injuries even after long storage, the lesions remaining comparatively superficial" (15).

In experiments with South African Valencia oranges, Kidd and Tomkins (61) have described a pronounced physiological breakdown as occurring at 5°C. (41°F.) and 1°C. (33.8°F.) towards the end of the storage life. Superficial spotting (*i.e.*, pitting) was characteristic of fruits stored at 5°C. At 1°C. the characteristic breakdown consisted in the development of large pale brown blemishes, the flesh being water-logged in appearance and of disagreeable odour.

Using Trinidad grapefruit the first symptoms of chilling have been produced experimentally by exposing fruits to a temperature of 35°F. and R.H. of 75 per cent. for 7 days; definite spotting appeared after 13 days. On the other hand, definite chilling could not be observed in fruit maintained at 35°F. in a saturated atmosphere until the 17th day. Similar blemishes have also been produced at 40°F. and at 45°F., after 45 days. In storage trials it has been shown that rate of air movement and atmospheric humidity are important in determining the rate at which chilling injury will become manifest (64). Even where definite chill blemishes have not developed evidence that fruits have been exposed to too low temperatures may be evident in the increased wastage which develops when fruits are removed to a higher temperature (63, 64).

In experiments with Jaffa oranges in trays, Bates (15.II) observed pitting in ethylene-coloured fruit after 10 days at 36°F.; instances of mild pitting in Valencias after 7 days, followed by severe pitting after 14 days, at 36°F., are also cited. Less severe pitting was observed at 40°F. As a rule oranges highly coloured at picking were more subject to pitting than green or partly coloured fruit: if highly coloured by ethylene, fruit was also subject to severe pitting. In contrast to this finding Hawkins and Barger (57) recommend stove-gas treatment as a partial control for pitting. According to Bates (15.II) "It is usually considered that early Citrus fruit is more liable than late to physiological injury in cold storage. On the other hand, over-mature fruit is also stated to be very subject to cold storage injury. There would thus appear to be a certain period during the ripening of Citrus fruits when they are comparatively resistant to physiological storage breakdown." In general he found that the most severe pitting occurred in ethylene-coloured oranges placed in cold storage immediately after picking. There is evidence that cured or wilted grapefruit and oranges are less subject to pitting than fruits which have not been wilted.

Most pitting develops during the first 3 to 4 weeks of storage (15) and only becomes slightly more intensive with more prolonged storage, *i.e.*, 11 to 12 weeks.

In Southern Rhodesia, Navel and Jaffa oranges showed the greatest susceptibility to pitting; Valencias were fairly susceptible, but the lesions tended to be superficial, even after prolonged storage. No pitting or other skin blemishes developed in Mediterranean Sweet oranges stored exposed at 36°F. (15.II)

Oiled wrappers (71), waxed papers (49) and vaseline smears (15.II), aluminium foil, &c. (46) have been found to give some control or reduction of pitting: this is presumably in relation to the reduction of desiccation and hence in the manifestation of chilling. Marks, blemishes or injuries to fruit prior to storage, and pressure marks due to tight packing, have been found to increase the intensity of pitting. Friend and Bach (49) observed more pitting in grapefruit in the bulge pack as compared with fruit in boxes without a bulge. Pitting lesions may afford a means of easy ingress for pathogens (15). As a means of preventing pitting in Florida citrus fruit a number of new treatments have been tried by Camp and Stahl (23). Oranges and grapefruit were kept for 14 weeks with very little pitting and decay when treated with borax, followed by a coating of commercial wax emulsion (Carnauba wax 80 per cent. and paraffin 20 per cent.), followed by wrapping in moisture-proof wraps. The optimum storage temperature is cited as 37.5°F. Moisture-proof box liners, made so as to encase completely the fruit in the half-section of a standard citrus case, were also found to be very efficacious; when used in conjunction with water-proof wrappings on individual fruits very good results were obtained.

The nature and detection of freezing injury in mature oranges while still on the tree or during transport has been investigated by Davis (36) and other workers. The usual symptom, an uneven drying out and collapse of the pulp vesicles, is detrimental to consignments during marketing.

Prolonged Storage.

The question of prolonged storage of grapefruit and oranges may arise during periods of high production, when it becomes desirable to withhold fruit until markets are more favourable. This contingency has had to be faced in several

countries. The problem involves economic aspects, the maintenance of desirable colour, flavour and firmness, the control of physiological blemishing and fungal rotting. Biochemical studies (2) indicate the following important changes in grapefruit during storage: (i) decrease in sugar content; (ii) increase in total solids (Brix); (iii) increase in the sugar : acid ratio; (iv) decrease in acid content; (v) increase in the ratio of volume of fruit to volume of juice; (vi) decrease in ratio of weight to volume of fruit; (vii) decrease in percentage rind.

During storage at 42° or 45°F., it was found that relatively slight changes took place in the titratable acidity of Trinidad-grown, seeded grapefruit (Duncan and Walters) during 85 days (64). This is in agreement with the work of Bates (13) and Friend and Bach (49). It has also been observed that flavour may be poor in long-stored fruit although the acidity and sugar contents have undergone comparatively little change (49, 64).

In tests, extending over two seasons, with Southern Rhodesian Valencia oranges arriving in England, it was shown that early season fruit could be held for 6 weeks in cold storage (ex-ship) with little wastage, whereas late season fruit developed extensive wastage after only 4 weeks in storage (15). Other experiments showed that different varieties can be held for 10 weeks (ex-tree) in storage without excessive wastage. Generally speaking the longer fruit is held in cold storage the more rapidly it deteriorates on removal to higher temperatures.

Delayed Picking (*i.e.*, Storage on the Tree).

According to Hawkins and Barger (57), writing in 1926, Florida grapefruit for late storage should not be left on the tree too long as it is liable to breakdown in storage or soon after it is removed for marketing. Seeded fruit should be placed in storage before the seeds begin to sprout. Uncured fruit (*i.e.*, quailed for less than 1 to 2 weeks at 70° to 75°F. and R.H. 65 per cent.) should not be stored for more than 6 weeks to 2 months; but cured fruit is stated to remain in good condition for 2 to 3 months at 32°F. without danger of excessive pitting.

In attempting to avoid unfavourable marketing periods, the question has arisen in Trinidad as to the advisability of leaving mature grapefruit, which in other circumstances would normally be picked for export, on the tree (64). Fears have been expressed that disproportionate losses might be sustained, either through excessive fruit dropping, or from deterioration in quality due to delayed picking of ripe fruit. Neither of these eventualities was realised, and on the whole planters have benefited financially by the procedure adopted. Fruits were taken from a single Marsh tree in the middle of March and again towards the end of April and a series of individual fruits analysed for acidity and internal gas concentrations as indicating physiological changes. Only a slight decrease in acidity was observed between the two pickings while internal gas concentrations remained unchanged. No change in flavour was apparent. The evidence available indicates, that, where necessary, ripe fruit may safely be left on the tree for a considerable time. The effect of such delayed picking on the subsequent cropping of the tree will require attention.

Investigations reported from Australia (29, 30) indicate that the time of picking of oranges in relation to their maturity as determined by the climacteric rise in respiration is of extreme importance in successful storage:

> "Delaying the picking time reduces the subsequent storage life by the length of time the fruit is allowed to remain on the tree. In consequence no advantage can be gained by cool storing fruit for local consumption, since as long, and in some instances, a longer storage life was obtained by leaving the fruit on the tree. Leaving the fruit on the tree would save cool storage and handling charges and eliminate the risk of any cool storage injuries . . .
>
> The storage life was terminated in some instances by loss of flavour, and, in others, by mould attack. Examinations were made after the fruit had been out of cool store for a week under atmospheric conditions (55°F. approx.)" (30).

In Florida, Camp *et al.* (22) found a more pronounced decrease in the percentage juice and titratable acidity in stored Valencia oranges as compared with those on the tree and state that the marketable period after removal from storage is shorter the more mature the fruit are at the time of storage.

Gas Storage.

Little critical information has been published on the gas storage of citrus. Thornton (97) found oranges and grapefruit quite resistant to carbon dioxide injury over short periods. He held Valencia oranges and Foster and Thompson grapefruit for 7 days at temperatures of 0°, 4° 10° and 15°C. (32°, 39.2°, 50° and 59°F.) in atmospheres containing 50 per cent. CO_2, without injury; tangerines and Walters grapefruit were injured by 50 per cent. CO_2 but not by 25 per cent. On the other hand, using Trinidad-grown grapefruit, it has been observed that exposure of fruits to CO_2 concentrations of 5 per cent. and 10 per cent. promotes wastage, *B. theobromae* being the principal organism involved (64). A type of blemishing due to gas injury is described in an earlier section. Recent work in Australia (5) indicates that 5 per cent. CO_2 is inimical to the storage of Washington Navel oranges.

In gas storage experiments with Florida grapefruit and oranges Camp and Stahl (23) have recorded good results at 37.5°F. The fruit was held in sealed containers; by absorbing the CO_2 of respiration a condition was produced in which the oxygen concentration was low and the humidity was high.

Brooks, Bratley and McColloch (18) found that Marsh grapefruit, exposed for 2 to 3 days to an atmosphere of carbon dioxide, 60 per cent. falling to 30 per cent. and temperatures falling from 75° to 50°F., prior to shipment and storage at 32°F. for 8 weeks, sustained no injury to flavour or appearance. In experiments on the effect of carbon dioxide treatment on citrus decay organisms inoculated into grapefruit, they found that *Diplodia natalensis* Evans, was inhibited least, with the other fungi in the following order *Phomopsis citri*, *Penicillium digitatum* and *P. italicum*. The inhibiting effect of carbon dioxide was of very much less practical value at lower temperatures.

From the economic standpoint gas storage of citrus may prove important. Thus Brooks *et al.* (18) observed that exposure of fruits to 43 to 45 per cent. of carbon dioxide at 77° to 79°F. had a checking effect that was approximately equivalent to the following reductions in temperature: in the case of *Diplodia to* an 8° drop; *Phomopsis*, to a 13° drop; *Penicillium digitatum*, to a 23° drop; *P. italicum*, to a 33° drop. Most of this contrast between the different fungi is due to a difference in the minimum temperature for the growth of the organisms. *Diplodia* and *Phomopsis* are held completely in check at 40°, whereas both species of *Penicillium* are capable of producing serious decay at as low a temperature as 32°F.

In experiments to determine whether a short period of exposure to carbon dioxide gas would affect the development of pitting in subsequent cold storage, Brooks and McColloch (19) found that after an exposure for 2 days to atmospheres containing 20 to 45 per cent. CO_2 at temperatures ranging from 41° to 77°F. less pitting occurred in grapefruit after 10 to 12 weeks storage at 32°F. than in untreated fruit. They add, however, that there was an average of one third as much disease in the treated as in the untreated fruit, the contrast being greater with the fruit held at the higher temperatures during the period of treatment. In later experiments in which the gas treatment consisted of exposure to 20 per cent. CO_2 for 30 hours, or 35 per cent. for 20 hours at about 50°F. the treated fruit again developed less pitting during storage at 32°F. and the shorter treatment apparently gave better results. The flavour of the fruit was unaffected. (*See* also Barker (11) under Blemishing due to Accumulated Gases.)

Culture, Production and Storage Quality.

Cultural treatments are important in such questions as the shedding of young fruits, fruit set, time of maturity, texture of ripe fruit and keeping quality in storage (2).

In Arizona experiments it was observed that with the Navel orange in a light-crop year, girdling the trees at full blossoming was more effective in maintaining the production of the previous year than any fertilizer treatment. With grapefruit, supplementary applications of nitrogen in late winter tended to reduce shedding and to increase yield. Extra quantities of manure (20 tons per acre) tended to produce larger and somewhat coarser fruit and to delay maturity. The application of phosphoric acid produced indefinite or negative benefits. Nitrogen-starved trees produced fruit which coloured early, had a low acid content and matured early but the rind was thick and the juice content low. Conclusions to date from Arizona experiments indicate that the fruiting behaviour of citrus is more closely associated with the nitrogen supply during the winter and spring months than with any other nutrient material (2).

References.

1. Adams, D. B.—Experiments in Citrus Fruit Storage. *Jour. Dept. Agr. Victoria*, XXI, 5, 1923.
2. Agricultural Research in Arizona. *Univ. of Arizona, Coll. of Agr., Agr. Exp. Sta. Ann. Rept.*, 1934.
3. Allen, F. W. and Pentzer, W. T.—The Influence of Humidity in Cold Storage Rooms upon Transpiration and Mold Growth of Fruit. *Ice & Refrig.*, LXXXVIII, 6, 1935.
4. Australia. Export of Oranges. Conditions of Guarantee. *Jour. Dept. Agr. Victoria*, XXXI, 1933.
5. Australia. *Counc. Sci. Ind. Res. Tenth Ann. Rept.*, 1936.
6. Baier, W. E.—Maturity Studies of California and Arizona Marsh Grapefruit. *Calif. Citrograph*, XVII, 94, 1932.
7. Baker, R. E. D.—Citrus Fruit Rots in Trinidad. *Tropical Agriculture*, XII, 6, 1935.
8. Baker, R. E. D. and Wardlaw, C. W.—Studies in the Pathogenicity of Tropical Fungi. I. On the Types of Infection Encountered in the Storage of Certain Fruits. *Ann. Bot. N.S.* I, 1, 1937.
9. Barger, W. R. and Hawkins, L. A.—Borax as a Disinfectant for Citrus Fruit. *Jour. Agr. Res.*, XXX, 2, 1925.
10. Barger, W. R. and Hawkins, L. A.—Colouring Citrus Fruit in Florida. *U. S. Dept. Agr. Bul.*, 1367, 1926.
11. Barker, J.—The Effect of Carbon Dioxide on Oranges. *Ann. Rept. Food Invest. Bd.*, 1927. *Dept. Sci. & Ind. Res.*, H.M.S.O. 1928.
12. Barrett, O. W.—The Tropical Crops. *The Macmillan Coy., New York*, 1928.
13. Bates, G. R.—I. The Development of the Artificial Colouration of Oranges in Southern Rhodesia and its Relation to Wastage. II. Wastage during the 1932 Export Season. III. Maturity Test Data, 1932. *Brit. S. Africa Coy. Mazoe Citrus Exp. Sta. Pub.* 2c, 1933.
14. Bates, G. R.—The Loss in Weight of Oranges between Grove and Market. *Brit. S. Africa Coy. Mazoe Citrus Exp. Sta. Pub.* 3c, 1934.
15. Bates, G. R.—I. Studies on the Infection of Citrus Fruits. (i) Some Methods of Infection by the Green Mould *Penicillium digitatum*, Sacc. II. Storage Tests with Rhodesian Oranges during 1934. *Brit. S. Africa Coy. Mazoe Citrus Exp. Sta. Pub.* 4b, 1936.
16. Benton, R. J. and Bowman, F. T.—Citrus Maturity Tests. *Agr. Gaz. N. S. Wales*, XLIII, 1932.
17. Bigelow, W. D. and Gore, H. C.—Ripening of Oranges. *Jour. Chem. Soc.*, XXIX, 1907.

18. Brooks, C., Bratley, C. O. and McColloch, L. P.—Transit and Storage Diseases of Fruits and Vegetables as Affected by Initial Carbon Dioxide Treatments. *U. S. Dept. Agr. Tech. Bul.* 519, 1936.
19. Brooks, C. and McColloch, L. P.—Some Storage Diseases of Grapefruit. *Jour. Agr. Res.*, LII, 5, 1936.
20. California Fruit-Growers Exchange. Colouring Citrus Fruit. June, 1932.
21. Camargo, F. C.—Fructicultura. A Laranja Para a Exportacao Deva ser Colhida Perfeitamente Madura. *Nouvi Ann. Minist. Agric. Roma*, 1928, p. 403. *Int. Bul. Inf. Refrig.*, IX, 1121, 1928.
22. Camp, A. F., Gaddum, L. W. and Stahl, A. L.—A Study of the Effect of Maturity and Temperature on the Storage of Valencia Oranges. *Florida Agr. Exp. Sta. Ann. Rept.*, 1933, p. 104.
23. Camp, A. F. and Stahl, A. L.—Cold Storage Studies of Citrus Fruits. *Florida Agr. Exp. Sta. Ann. Rept.*, 1935, p. 81.
24. Chace, E. M. and Church, C. G.—Effect of Ethylene on the Composition and Colour of Fruits. *Jour. Ind. & Eng. Chem.*, XIX, 10, 1927.
25. Chace, E. M. and Denny, F. E.—Use of Ethylene in the Colouring of Citrus Fruit. *Jour. Ind. & Eng. Chem.*, XVI, 4, 1924.
26. Chen, S. H.—Storage of Citrus Fruits. I. *Univ. Nanking Coll. Agr. & For. Bul.* 28, *N.S.*, 1934.
27. Citrus Fruit Law. The State of Florida, Dept. of Agric., Inspection Bureau.
28. Citrus Preservation Committee. Progress Report. *Jour. Counc. Sci. & Ind. Res.* Australia, V, 4, 1932.
29. Citrus Preservation Investigations. *Counc. Sci. & Ind. Res. Ann. Rept. Australia*, 1934.
30. Citrus Preservation Investigations. *Counc. Sci. & Ind. Res. Ann. Rept. Australia*, 1935.
31. Copeman, P. R. v.d.—Changes in the Composition of Oranges during Ripening. *Trans. Roy. Soc. S. Africa*, XIX, 1931. *Index to Lit. on Food Investig.*, III, 2, 1931.
32. Copeman, P. R. v.d. R.—Variation in the Fruits of Washington Navel Oranges with Reference to the Standardization of Quality by Means of the Sugar/Acid Ratio. *Jour. Pom. & Hort. Sci.*, XII, 1934.
33. Croucher, H. H.—Maturity Tests for Citrus. *Dept. Sci. Agr. Jamaica, Bul.* 5. (*N.S.*) 1935.
34. Davies, R.—Survey of Temperature Conditions and Gas Concentrations in Refrigerated Chambers on arrival at Southampton in Ships carrying Citrus from South Africa. *Union of S. Africa, Dept. Agr. Sci. Bul.* 117, 1932.
35. Davies, R.—Fungal Invasion of Navel Oranges. *Rept. Low Temp. Res. Lab. Capetown*, 1933. *Union of S. Africa, Dept. Agr. & For.* 1935.
36. Davis, W. B.—Detection and Measurement of Freezing Injury in Valencia Oranges. *Amer. Jour. Bot.* XXII, 5, 1935.
37. De Leon, J.—Progress Report on the Storage and Curing of Mandarin Oranges at the Tanauan Citrus Experiment Station. *Philippine Agr. Rev.* XXI, 2, 1928.
38. Denny, F. E.—Hastening the Coloration of Lemons. *Jour. Agr. Res.*, XXVII, 10, 1924.
39. Denny, F. E.—Effect of Ethylene upon Respiration of Lemons. *Bot. Gaz.*, LXXVII, 3, 1924.
40. De Villiers, F. J.—Citrus Maturity Test. Directions for Testing Export Oranges for the Sugar/Acid Ratio. *Dept. Agr., Union of S. Africa, Bul.*, 37. *Pretoria* 1928.
41. De Villiers, F. J.—Some Factors which affect the Brix-Acid Ratio of Oranges. *Dept. Agr. Union of S. Africa Sci. Bul.*, 103, *Pretoria*, 1931.
42. Experiments with Oranges. *Ice & Refrig.*, XCI, 5, 1936.
43. Fawcett, H. S.—A Spotting of Citrus Fruits due to the Action of Oil Liberated from the Rind. *Univ. Calif. Agr. Exp. Sta. Bul.*, 266, 1916.
44. Fawcett, H. S.—Citrus Diseases and their Control. *McGraw Hill Coy., New York and London*, 1936.
45. Fawcett, H. S. and Barger, W. R.—Relation of Temperature to Growth of *Penicillium italicum* and *P. digitatum* and to Citrus Fruit Decay Produced by these Fungi. *Jour. Agr. Res.*, XXXV, 10, 1927.
46. Fifield, W. M.—The Effect of Various Wrappers on the Preservation of Oranges in Cold Storage. *Univ. Florida Agr. Exp. Sta.*, April, 1932. *Int. Bul. Inf. Refrig.*, XIV, 4, 19690, 1933.
47. *Florida Univ. Agr. Exp. Sta. Ann. Rep.*, 1933. Horticulture, p. 87.
48. Friend, W. H.—Cold Storage of Citrus Fruits. Recent Research in Mould Spots and Pitting. *Ice & Cold Storage*, XXXVI, 425, 1933.
49. Friend, W. H. and Bach, W. J.—Storage Experiments with Texas Citrus Fruits. *Texas Agr. Exp. Sta. Bul.* 446, 1932.
50. Fulton, H. R. and Bowman, J. J.—Preliminary Results with the Borax Treatment of Citrus Fruits for the Prevention of Blue Mold Rot. *Jour. Agr. Res.*, XXVIII, 9, 1924.
51. Fulton, H. R. and Bowman, J. J.—Effect of Spraying with Fungicides on the Keeping Quality of Florida Citrus Fruits. *U. S. Dept. Agr. Dept. Circ.* 409, 1927.
52. Fulton, H. R., Stevens, H. E. and Wootten, J. F. —Injuries and Rots that may follow the use of Gases in the Colouring of Florida Citrus Fruits. *Proc. Florida State Hort. Soc.*, 1929. *Biol. Abstr.*, VI, 2, 21414, 1932.
53. Grasovsky, A. and Shiff, M.—The Effect of Ammonium Bicarbonate on the Storage of Oranges. *Hadar*, VII, 7, 1934.
54. Green, F. M.—The Infection of Oranges by Penicillium. *Jour. Pom. & Hort. Sci.*, X, 1932.
55. Harvey, R. B.—Artificial Ripening of Fruit and Vegetables. *Univ. Minn. Agr. Exp. Sta. Bul.*, 247, 1928.
56. Hawkins, L. A.—A Physiological Study of Grapefruit Ripening and Storage. *Jour. Agr. Res.*, XXII, 5, 1921.
57. Hawkins, L. A. and Barger, W. R.—Cold Storage of Florida Grapefruit. *U. S. Dept. Agr. Bul.*, 1368, 1926.
58. Henricksen, H. C.—Colouring of Citrus Fruit. *Agr. Notes, Porto Rico*, No. 40, 1928.
59. Henricksen, H. C.—The Colorability of Grapefruit. *Agr. Notes, Porto Rico*, No. 50, 1929.
60. Hodgson, R. W.—Some Abnormal Water Relations in Citrus Trees of the Arid South-West and their possible Significance. *Univ. Cal. Publ. in Agr. Sciences*, III, 3, 1917.
61. Kidd, M. N. and Tomkins, R. G.—An Analytical Study of the Mortality of Orange Fruits at Various Constant Temperatures. *Dept. Sci. & Ind. Res. London, Food Invest. Board Ann. Rept.*, 1927.

62. Klotz, L. J. and Haas, A. R. C.—Some Differences between Button-Blossom Halves of Citrus Fruits. *Cal. Citrograph*, XVIII, II, 1933.
63. Leonard, E. R.—The Storage of Trinidad Citrus Fruits. *Low Temp. Res. Sta. Mem.*, 2, *I.C.T.A., Trinidad*, 1936.
64. Leonard, E. R. and Wardlaw, C. W.—Storage Investigations with Trinidad Citrus Fruits 1935-36. *Low Temp. Res. Sta. Mem.*, 6,, *I.C.T.A., Trinidad*, 1937.
65. Lutz, J. M. and Winston, J. R.—Colouring Citrus Fruits in Texas. *Texas Citriculture*, VII, 8 and 9, 1932.
66. Mann, C. W.—The Handling of Porto Rican Oranges, Grapefruit and Pineapples. *Porto Rico Ins. Exp. Sta. Bul.*, 7, 1914.
67. Mann, C. W. and Cooper, W. C.—Refrigeration of Oranges in Transit from California. *U. S. Dept. Agr. Tech. Bul.* 505, 1936.
68. Marloth, R. H.—The Influence of Hydrogen-ion Concentration and of Sodium Bicarbonate and Related Substances on *Penicillium italicum* and *P. digitatum*. *Phytopath*, XXI, 2, 1931.
69. McClelland, T. B., Bregger, T., Snyder, W. P. *et. al.*—Horticultural Investigations at the Porto Rico Station. *Porto Rico Agr. Exp. Sta. Rept.*, 1923, pp. 4-18.
70. Method of Making the 8 : 1 test for Oranges. *State of Calif. Dept. Agr. Circ.*, Nov., 1920.
71. Nelson, R.—Some Storage and Transportational Diseases of Citrus Fruits Apparently due to Suboxidation. *Jour. Agr. Res.*, XLVI, 8, 1933.
72. Onslow, M. and Barker, J.—The Alcohol Content of Oranges and its Diagnostic Value. *Dept. Sci. & Ind. Res. London, Food Investig. Ann. Rept.*, 1927, p. 35.
73. Orange Pre-cooling Plants in California. *Ice & Refrig.*, XCI, 6, p. 456, 1936.
74. Overholser, W. L.—A Study of the Shipment of Fresh Fruits and Vegetables to the Far East. *Univ. Calif. Agr. Exp. Sta. Bul.*, 497, 1930.
75. Palestine Orange Shipments. *E.M.B.*, 68, 1933. (*London : H.M. Stationery Office.*)
76. Plank, J. E. van der.—Sooty Blotch of Oranges. *Farming in S. Africa*, VI, 72, 1932.
77. Poole, G.—U.S.A. Association of Refrigerated Warehouses. Report of Research Committee. *Ice & Refrig.*, LXXXVIII, 5, 1935.
78. Powell, G. H., Stubenrauch, A. V., Tenny, L. A., Eustace, H. J., Hosford, G. W. and White, H. M. —The Decay of Oranges while in Transit from California. *U. S. Dept. Agr. Bur. Plant. Ind. Bul.*, 123, 1908.
79. Powell, H. C.—The Citrus Industry in Palestine. *Government Palestine Dept. Agr. & For. Agr. Leaflet, Series*, IV, *Hort.* No. 9.
80. Powell, H. C.—The Culture of the Orange and Allied Fruits. *S. African Agric. Ser.* 8. *Central News Agency Ltd. S. Africa*, 1930.
81. Powell, H. C.—The Economic Importance of the Citrus Industry in South Africa. *Univ. Pretoria*, Ser. 1, 24, 1933.
82. Powell, H. C. and Matthews, I.—Ethylene Colouring of Citrus Fruit. *Univ. Pretoria*, Ser. 1, 25, 1933.
83. Putterill, V. A.—Citrus Wastage Investigations. Progress Report No. 3, Season, 1934, *Dept. Agr. & For. Union of S. Africa, Bul.*, 149, 1935.
84. Putterill, V. A. and Davies, R.—Citrus Wastage Investigations carried out at Zebediela, Transvaal, during the Seasons 1931 and 1932. *Union of S. Africa, Dept. Agr. Bul.*, 128, *Pretoria*, 1934.
85. Ranger, W. and Young, W. J.—The Export of Oranges. *Counc. Sci. & Ind. Res. Australia, Pam.*, 7, 1928.
86. Refrigerating Data Book. *Publ. Amer. Soc. Refrig. Eng.* 3rd Edn. 1936.
87. Reichert, I. and Hellinger, E.—Control of Diplodia Stem-End Rot of Citrus. *Hadar*, III, 6, 1930.
88. Reichert, I. and Hellinger, E.—Further Experiments on the Control of Diplodia Stem-End Rot of Citrus Fruits by De-Buttoning. *Hadar*, IV, 10, 1931.
89. Reichert, I and Hellinger, E.—Further Experiments on the Control of Diplodia Stem-End Rot of Citrus by Pruning and Spraying. *Hadar*, V, 6, 1932.
90. Reichert, I. and Hellinger, E.—Penicillium Rot of Oranges and the Conditions Affecting its Appearance in Palestine. *Hadar*, VI, 4, 1933.
91. Reichert, I. and Littauer, F.—Preliminary Disinfection Experiments against Mould Wastage in Oranges. *Hadar*, IV, 3 and 4, 1931.
92. Rept. Low Temp. Res. Lab., Capetown, 1933. *Union of S. Africa, Dept. Agr. & For., Pretoria*, 1935.
93. Savastano, G. and Fawcett, H. S.—A Study of Decay in Citrus Fruits produced by Inoculations of Known Mixtures of Fungi at Different Constant Temperatures. *Jour. Agr. Res.*, XXXIX, 3, 1929.
94. Sievers, A. F. and True, R. H.—A Preliminary Study of the Forced Curing of Lemons as practised in California. *U. S. Dept. Agr. Bur. of Plant Ind. Bul.*, 232, 1912.
95. Smith, F. E. V.—Stem-End Rot of Citrus and its Control in the Packing House. *Jour. Jamaica Agr. Soc.*, XXXVI, 2, 1932.
96. Stubenrauch, A. V., Ramsey, H. J. and Tenny, L. S.—Factors Governing the Successful Shipment of Oranges from Florida. *U. S. Dept. Agr. Bul.*, 63, 1914.
97. Thornton, N. C.—The Effect of Carbon Dioxide on Fruits and Vegetables in Storage. *Contrib. Boyce Thompson Inst.*, III, 2, 1931.
98. Tindale, G. B.—Valencia Late Oranges. Cool Storage Experiments. *Jour. Dept. Agr. Victoria*, XXV, 5, 1927.
99. Tindale, G. B.—Cool Storage of Washington Navel Oranges. Results of 1926 Experiments. *Jour. Dept. Agr. Victoria*, XXV, 2, 1927.
100. Tomkins, R. G.—Iodised Wraps for the Prevention of Rotting of Fruit. *Jour. Pom. & Hort. Sci.*, XII, 1934.
101. Tomkins, R. G. and Trout, S. A.—The Use of Ammonia and Ammonium Salts for the Prevention of Green Mould in Citrus. *Jour. Pom. & Hort. Sci.*, IX, 4, 1931.
102. United States Department of Agriculture Leaflet entitled Sweating of Citrus Fruits by the Ethylene Gas Method. *U. S. Dept. Agr. Bur. of Chem.*, 1926, revised 1930.
103. Wardlaw, C. W.—Iodine and the Control of Fungal Wastage. *Tropical Agriculture*, XIII, 5, 1936.
104. Wardlaw, C. W. and Leonard, E. R.—Antiseptic and Other Treatments in the Storage of Trinidad Citrus Fruits. *Low Temp. Res. Sta. Mem.*, 5, *I.C.T.A., Trinidad*, 1937.
104A. Wardlaw, C. W., Leonard, E. R. and Baker, R. E. D.—Observations on the Storage of Various Fruits and Vegetables, II. *Tropical Agriculture*, XI, 9, 1934.

105. Weston, B. J.—Picking, Grading and Packing of Citrus Fruits. *Dept. Agr. Bul.*, 2, *Hort. Ser. Cyprus*, 1933.
106. Williams, W. J.—The Cold Storage of Grapefruit in Australia. *Ice & Refrig.*, LXXXV, 3, 1933.
107. Winston, J. R.—Some Factors Influencing Decay in Florida Citrus Fruits. *Citrus Industry*, XIV, 5, 1933.
108. Winston, J. R.—Preparation and Packing of Oranges for Shipment. *Ind. & Eng. Chem.*, XXVI, 7, 1934.
109. Winston, J. R.—Reducing Decay in Citrus Fruits with Borax. *U. S. Dept. Agr. Tech. Bul.*, 488, 1935.
110. Winston, J. R.—A Method of Harvesting Grapefruit to Retard Stem-End Rot. *U. S. Dept. Agr. Circ.* 396, 1936.
111. Winston, J. R., Fulton, H. R. and Bowman, J. J. —Commercial Control of Citrus Stem-End Rot. *U. S. Dept. Agr. Dept. Circ.*, 293, 1923.
112. Wright, R. C.—Colouring Satsuma Oranges in Alabama. *U. S. Dept. Agr. Dept. Bul.*, 1159, 1923.
113. Young, W. J. and Read, F. M.—Experiments on the Preservation of Citrus Fruits. *Proc. 1st Imp. Hort. Conf. London*, Part III, 1930.
114. Young, W. J. and Read, F. M.—An Experimental Shipment of Navel Oranges to Canada. *Jour. Dept. Agr. Victoria*, XXIX, 1931.

OBSERVATIONS ON THE PUPAL DIAPAUSE OF THE ORANGE DOG (*PAPILIO ANCHISIADES* L.)

By F. A. Squire.

The enigma of diapause or dormancy in insects is not only profoundly interesting but also of considerable economic importance since it complicates the life-history of certain pests, rendering them more difficult to control; yet it is but little understood, and no satisfactory theory has so far been advanced to account for it. According to Roubaud (1, 2) it is due to a cyclic accumulation of waste products and takes place during spells of cold or low relative humidity.

It is necessary, however, to distinguish between hibernation, aestivation and other similar phenomena induced by unfavourable conditions and spontaneous pauses in development. Heller, cited by Uvarov (3), considers that true diapause is a Mendelian character not influenced by environment.

A typical case of diapause that is apparently independent of external factors occurs in the Orange-dog (*Papilio anchisiades* L.). The following observations on this butterfly were made in British Guiana during 1935. The temperature ranged from 65°F to 84°F and the relative humidity from 60 per cent. to 95 per cent., the mean being about 75 per cent.

The life history may briefly be described as follows:—The eggs which are laid on orange leaves hatch in six days. The caterpillars are markedly gregarious during the whole larval period and there is little doubt that they have much the same alimentation. There are indeed a few stragglers in every brood, but these, on being separated, proved to have no bearing on the question of diapause. The pupae are threaded to the bark of the orange tree exposed to the wind and rain but concealed from natural enemies by their remarkable protective resemblance. The normal pupal period is 12 to 14 days, but in every brood at least one-third of the individuals have a diapause.

The following table is typical of several dozen broods observed over a period of one year:—

Forty-eight pupae (collected as full grown larvae). Of these—

9 male(s)	and 13 female(s)	emerged on time.		
1	,,		after 17	days.
3		,,	,, 36	,,
1		,,	,, 41	,,
1		,,	,, 45	,,
1		,,	,, 47	,,
1		,,	,, 48	,,
1		,,	,, 58	,,
1	,,		,, 62	,,
1	,,		,, 64	,,
2	,,		,, 66	,,
1		,,	,, 70	,,
1	,,		,, 72	,,
1		,,	,, 73	,,
1	,,		,, 75	,,
1	,,		,, 77	,,
2	,,		,, 86	,,
1		,,	,, 100	,,

The pupae were all kept subject to the same conditions in cages on damp sand. It will be seen that nearly three-fifths of the individuals went into diapause. This fraction was quite usual in the broods observed. In a few instances it was greater and in no case did it fall below one-third. It is evident that the diapause may range from a few days to over three months. Furthermore it takes place in the same degree all the year round and the prevailing season or weather has no apparent influence on emergence. In many cases the pupae remained dormant for a period covering all types of local weather conditions.

In most insects there is a steady decline in pupal weight. Observations were made on this stage of *Papilio anchisiades* with a view to studying possible abnormalities in diapausing individuals. Fig. 1 shows the type of result obtained for a normal specimen. The instar lasted 13 days and the total loss was 14.9 per cent. Fig. 2 illustrates the same thing in a diapausing pupa. The instar was nearly three times the normal length; yet there was approximately the same loss in weight (14.3 per cent.). Nor was the loss significantly greater even in the longest diapauses observed. Pupae in diapause lose their weight by fits and

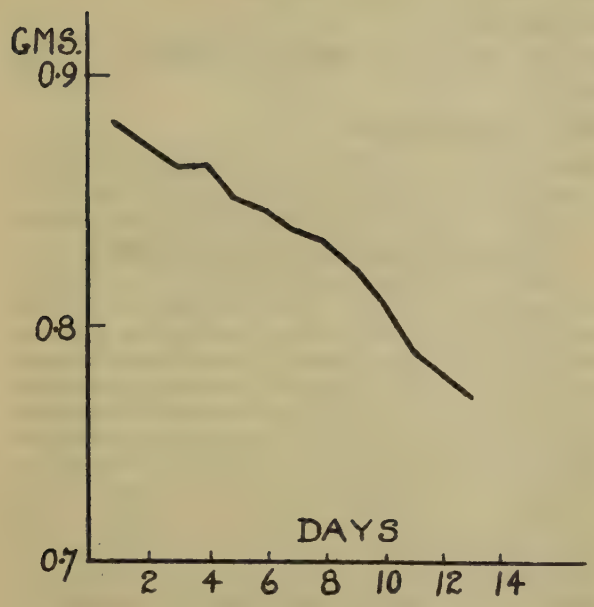

FIG. 1.—*Decline in pupal weight of P. anchisiades L., normal individual, total loss in weight* 14.9 *per cent.*

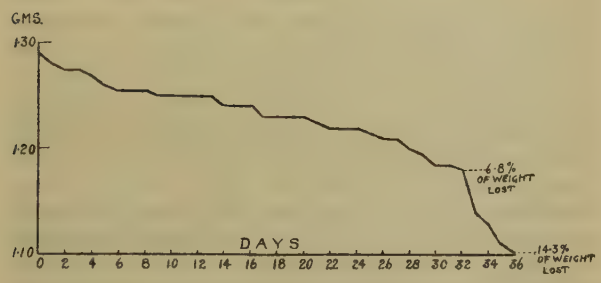

FIG. 2.—*Decline in pupal weight of P. anchisiades L., diapausing individual, total loss in weight* 14.3 *per cent.*

starts so that it may remain constant for four or five days. Moreover these pauses occur only until about 6 to 8 per cent. of the weight of the pupa has been lost, *i.e.*, about half of the total loss. After that the decline is practically uninterrupted.

There is little connection however between these losses and the physiological changes within; for, firstly, as shewn in a previous investigation (4) the loss is not in quantitative agreement with the CO_2 given off; and, secondly, considering the respiration curve (Fig. 3) for diapausing individuals of *Papilio anchisiades* given in (4) and reproduced here (C), it will be seen that the physiological changes as indicated by the respiratory rate proceed in a normal manner until the diapause sets in a day or two before emergence is due. The respiratory rate then drops almost to zero where it remains for the whole of the indefinite diapause.

Fig. 2 on the other hand has no correspondence with the respiratory curve except that the rapid fall at the end of the former may be indirectly correlated with the steep rise at the end of the latter; but even this is doubtful. The decline in pupal weight is due to loss of surplus moisture.

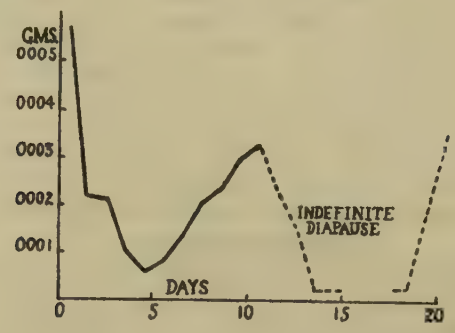

FIG. 3.—*Amount of* CO_2 *given off during one hour of successive days of the pupal period. Papilio anchisiades, Esp., four pupae, total weight* 4.53 *gms.*

Conclusions.

The conclusions to be drawn are:—

(1) Diapause is due to obligatory or facultative retardation in the loss of excess moisture in the manner illustrated by Fig. 2 by some unknown mechanism.

(2) The final histogenetic changes preceding emergence by 48 hours are inhibited by the presence of excess moisture and can only proceed when half of the latter has been eliminated.

(3) The physiological history of diapausing pupae is normal up to forty-eight hours before the end of the normal pupal period when it is interrupted by the diapause which indefinitely delays emergence.

(4) The loss of moisture, however, as indicated by the decline in pupal weight is abnormal and irregular from the beginning. At the end of the diapause it becomes rapid and uninterrupted.

(5) By what mechanism the pupa effects and regulates this dehydration remains to be investigated.

Finally, though this does not help to explain the cause or the *modus operandi* of diapause, it may be mentioned that its biological significance in this case at least is not far to seek since it obligates a certain amount of cross-fertilization in every generation.

References.

(1) Roubaud, E. 1927—L'hétérodynamie et le rôle de l'athermobiose dans le cycle évolutif de *Phlebotomus pappatatsii*. *Bull. Soc. Path. exot.* 20. 613.

(2) Roubaud, E. 1928.—L'anhydrobiose réactivante dans le cycle évolutif de la pyrale du mais. *Comptes rendus de l'. A cad. Sci.* Paris, 186. 792.

(3) Uvarov, B. P. 1931. Insects and climate. *Trans. Ent. Soc.* London, 79, 110.

(4) Squire, F. A. 1936.—Observations on the pupal respiration of some insects of economic importance. *Bull. Ent. Res.* 27. 3.

THE CACAO INDUSTRY OF TRINIDAD.—*Concluded.*

SOME ECONOMIC ASPECTS.

Series II.—A financial survey of estates during the seven years 1923-4 to 1929-30.

By C. Y. Shephard.

GENERAL SUMMARY AND CONCLUSIONS.

Of the information presented in this series of articles, part may be considered as primarily of interest, and possibly of value, to public bodies such as Government, and part as of chief utility to those engaged in the cacao industry. The first category embraces such matters as the economic organisation of the industry and its general financial condition, while the second is concerned with the revelation of those factors associated with profitable and unprofitable estates.

Economic Organisation.

Cacao estates are small in size compared with those devoted to sugar cane, and are owned, for the most part, by individuals who obtained much of the capital required for the development of their properties by means of mortgages. The industry occupied a large area and employed more labour than any other crop. Nearly all the capital is locally owned, and the industry came to be regarded as the 'financial barometer' of the Colony. The estates concentrate almost entirely on the production of cacao.

Financial Condition 1923-24 to 1929-30.

The price of cacao averaged $12.32 (£2 11*s.* 4*d.*) per fanega during the period 1923-4 to 1929-30, and estates were able to show yearly profits averaging $8.95 (£1 17*s.* 3½*d.*) per acre. The margin of profit proved much smaller than had been anticipated, owing partly to the fact that costs of production had crept from the generally accepted estimate of $10.00 (£2 1*s.* 8*d.*) to an average of $12.81 (£2 13*s.* 4½*d.*) per bag, and partly to yields being only 5.69 bags per 1,000 pickets (260 lb. per acre), instead of the popular estimate of ten bags (say 500 lb. per acre). Sharp variations in annual yields, and the wide divergence between records of individual estates tended to obscure these significant changes in the industry. Outstandingly good estates create a deep impression on the observer, and striking and unusual features tend to be interpreted as the normal. One of the most important functions of such an enquiry as the present one is to substitute reliable and comprehensive data for the impressions gathered from the restricted, and oftentimes abnormal, experience of the individual.

Range of Profits.

The range in the profitableness of the estates is astonishingly great, and it appears almost incredible that, with cacao at $12.32 (£2 11*s.* 4*d.*) per fanega, one group of estates, representing one quarter of the total number and acreage examined, operated at a loss. On the other hand, another group of estates, similar in number and acreage, would have shown profits even if the price of cacao had been only half that actually obtained. It is evident that the efficiency of the first group of estates has fallen to such a low level that the possibility of earning profits from cacao has permanently ceased. These estates constitute liabilities to their owners, rather than assets.

Financial Condition 1930-31 to 1935-6.

From 1930-31 to 1935-6 the price of cacao averaged $6.67 (£1 7*s.* 9½*d.*) per fanega, or little more than half that obtained during the previous seven years. The 'worst' estates were clearly incapable of withstanding this drastic depreciation in the price of cacao. The owners of many of the 'best' estates, too, experienced financial difficulties because of the existence of heavy mortages. Withdrawals by the owners were reduced, and expenditure on cultivation was severely curtailed, in an effort to maintain payment of interest on encumbrances. Unemployment, and more particularly under employment, became widespread in the cacao industry, and but for the relief afforded by the rapid expansion of the sugar industry, Government would have been faced with a situation of extreme gravity. The sugar industry itself was facing the most severe crisis in its history, but the greater financial stability of the companies, their happy exemption from the necessity of remunerating share holders, the skilful use of cost accounts, scientific investigations and mechanical equipment, enabled them to increase their efficiency at a rate even faster than the decline in sugar prices. Thus, despite record low prices, the sugar industry now operates at a profit. The measures adopted by the cacao planters were totally inadequate to meet the situation, and they found themselves incapable of paying interest on mortgages. The liability of many mortgages to foreclosure is of public as well as private concern.

Witchbroom.

The burdens of the cacao planter have been aggravated by the rapid spread of Witchbroom. A large section of the industry, probably at least one-third, was already so hopelessly inefficient that its abandonment was merely a question of time, and the appearance of witchbroom has merely abbreviated the period of survival. There is, however, another large section whose existence is threatened by this disease, and even the most efficient estates, if handicapped by heavy encumbrances, can view the situation only with apprehension. The mere abstention from the performance of operations hitherto considered essential to the maintenance of efficiency offers no solution to this grave economic problem. On the contrary, the vicious circle of neglected cultivation, intensified Witchbroom infection, falling yields, and diminished income, merely prejudices the future of the industry. The efficiency of the estates must be improved by the application of scientific methods, strict financial control, and, possibly, the modification of the

system of ownership by the formation of companies whose shareholders would not be entitled to demand remuneration at the expense of the efficiency of the estates. In the search for efficiency the examination of the factors associated with profitable and unprofitable estates provides relevant information.

Comparison of Estate Records.

The provision of tables showing the detailed records of estates grouped according to various criteria, such as costs of production, location, yields, size, expenditure on, and age of, cultivation, provided each planter an opportunity of comparing and contrasting his estate with similar and dissimilar groups of estates. The manager's attention was directed to those items on which expenditure was abnormally high or low, but the scope for economy thus presented is very limited. An examination of these tables shows that the most profitable estates obtained high yields, spent less than the average on cultivation, were about 300 acres in size, were young, purchased no manures, and in most cases, specialised almost entirely in the production of cacao. Of the factors associated with success it is important to distinguish those related as cause and effect.

Yields.

There is little doubt that yields and profits are closely related at any given price level, but this information is of little practical value unless it can be supplemented by the discovery of the factors responsible for differences in yield, and the extent to which conditions on the high yielding estates can be reproduced profitably on the low yielding estates. It can be said that differences between estates in yields are not related to differences in expenditure on cultivation. Some high yielding estates spend very little on cultivation, while some low yielding ones spend much above the average on cultivation. The inference that a decrease in the expenditure on cultivation would result in increased yields is, invalid, because the records refer to yields of different estates at a given time, and not to yields of the same estate at different times. No evidence has been submitted of the effect on yields of decreasing or increasing the expenditure on cultivation. Since 1929-30, however, the effect of neglecting cultivation has been clearly shown in reduced yields.

Manuring.

The fact that the lowest yielding estates applied small quantities of artificial manures, whereas the highest yielding estates purchased none, does not necessarily imply that yields were depressed by the application of manures. On the contrary, recent experiments have demonstrated that the application of suitable manures to certain soils doubles yields. It can be said that some estates experimented with manures because their yields were abnormally low, but not that their yields were abnormally low because they applied manures. There is little doubt that there will be a rapid increase in the purchase of artificial manures when the deficiencies of the various soil types are accurately assessed, and the application of manures can be proved profitable.

Degree of Specialization.

The most efficient of the older estates concentrate almost entirely on cacao, whereas the least efficient estates show appreciable diversification of crops. These facts do not prove that efficiency is the consequence of specialisation, or that inefficiency results from diversification The introduction of subsidiary crops is an indication that cacao had become unprofitable. Some degree of diversification is desirable as a means of reducing seasonal fluctuations in employment, and as a possible means of offering greater financial stability.

Size of Estate.

Estates of 300 acres earned greater profits than larger or smaller properties, but it is possible that the most efficient size lies outside the range of those examined. The future may lie with small-holdings worked by family labour, and large estates organised as companies, possessing great financial stability, and employing a highly skilled staff.

Mortgages.

The heavy encumbrances of the high yielding estates do not prove that they were enabled to borrow heavily by virtue of their high efficiency, nor are the small mortgages of the low yielding estates an indication that their development was cramped by restricted credit. Heavy indebtedness is evidence of continued ability to meet interest charges, and freedom from mortgages is usually the result of foreclosure consequent upon inability to meet interest charges.

Age of Cultivation.

The outstanding success of the young estates suggests that youth of cultivation plays an important part in determining yields and profits. This suggestion is not incompatible with the fact that the 'best' are older than the 'worst' estates in the Montserrat District. The information submitted in this series of articles relates to groups of estates of different ages and not to the same estates at different ages. The 'best' estates in the Montserrat District may have given, and in fact did give, higher yields when they were younger. But even if a relationship between age of cultivation and yields can be established it merely serves to raise the questions of what factors associated with age determine yield trends, and whether those responsible for declining yields can be counteracted by profitable measures. An increase in yields accompanied by a decrease in profits would defeat the principal aim of the planter.

Soil Type.

It is obvious, however, from the fine records of certain old fields and estates that whatever the influence of age on yields there are some factors of even greater importance. The fact that the most profitable estate is situated on soil recognised as being of exceptional fertility suggests that soil type constitutes one of the most important

of these factors. In the next series of articles an attempt is made to assess the influence of soil type and age of cultivation on yields of cacao.

Conclusion.

The examination of the records of a large number of cacao estates has served to establish certain facts, and to reveal factors associated with good and bad estates, but has provided little material from which recommendations for improving the efficiency of individual estates can be formulated. The purpose of this part of the investigation is merely to narrow the issue by suggesting factors worthy of more detailed investigations.

Acknowledgments.

I acknowledge with gratitude the cordial assistance rendered by the proprietors or managers of cacao estates, and particularly the ever-ready help and encouragement given by the late Hon. Carl de Verteuil. I am deeply indebted to those Post Graduate students and others who assisted me in the collection and analysis of estate records. From every member of the Imperial College of Tropical Agriculture and the Department of Agriculture I have invariably received the most generous co-operation. Sir Geoffrey Evans, Sir Norman Lamont, Bart., the Hon. E. J. Wortley, Professors Hardy, Wood, and Cheesman, Dr. C. W. Wardlaw and Mr. Carl de Verteuil, Jr., have been especially helpful in the preparation of these articles for publication.

Literature Cited.

1. Adamson, A. M.—Progress Report on the Introduction of a Parasite of the Cacao Thrips from the Gold Coast to Trinidad, B. W. I. *Tropical Agriculture*, Vol. XIII, No. 3, Trinidad, 1936.
2. Ballou, H. A.—Insect Pests of the Lesser Antilles. Pamphlet Series, No. 71. *Imperial Department of Agriculture for the West Indies, Advocate Co., Ltd.*, Barbados.
3. Briton-Jones, H. R.—The Diseases and Curing of Cacao, *Macmillan & Co.* London, 1934.
4. Gilbert, S. M.—Cacao Industry of Trinidad. Council Paper No. 4 of 1931, *Government Printing Office*, Trinidad.
5. Hart, J. H.—Cacao. *Duckworth & Co.*, London, 1911.
6. McDonald, J. A., Hardy, F. and Rodriguez, G.—Studies in West Indian Soils. (VII) The Cacao Soils of Trinidad. (A) Montserrat District. *Government Printing Office*, Trinidad, 1933.
7. Pound, F. J.—Annual Reports on Cacao Research 1931, 1932, 1933, 1934, 1935, *Government Printing Office*, Trinidad.
8. Shephard, C. Y.—Agricultural Labour in Trinidad. *Tropical Agriculture*, Vol. XII, Nos. 1, 2, 3, 4, 5, 6, 7, Trinidad, 1935.
9. Shephard, C. Y.—The Cacao Industry of Trinidad. Some Economic Aspects. Parts I to V.
   (*a*) Scope of Investigation.
   (*b*) General History of the Production and Consumption of Cacao.
   (*c*) History of the Industry up to 1870.
   (*d*) Historical 1870 to 1920.
   (*e*) Historical 1921 to 1932.
   Government Printing Office, Trinidad, 1932.
10. Shephard, C. Y.—Report on the Economics of Peasant Agriculture in the Gold Coast. No. 1 of 1936, *Government Printing Office*, Gold Coast.

Glossary.

Arrondeering = Ring weeding.

Bag = 165 lb. or 1½ fanegas.

Brushing = Cutting down weeds with a cutlass.

Cacao, wet. = Raw beans extracted from the pod. Dry cacao = cacao prepared for market by fermentation and drying. Cocoa = the manufactured product in powder form.

Cent. = c. = ½*d.* sterling.

Crook. = A piece of harness from which baskets of cacao are suspended pannier fashion.

Dollar. = $ = 4*s.* 2*d.* sterling.

Driver.—Foreman.

Fanega. = 110 lb. : 20 fanegas = 1 metric ton.

Garbling. = Cleaning. Removing waste and inferior material.

Jorquette. = fork of a tree. Presumably a corruption of the Spanish word "horcadura".

Picket. = A stick driven in the ground to mark the site for planting a tree.
1,000 pickets = 1 carré or quarrée = approximately 3 1-5 acres.

(*Note*: Cacao trees were usually planted 12 feet by 12 feet apart, and 1,000 pickets, or tree sites, represented an area of approximately one carré. On some estates, usually those in the Rio Claro District, a wider spacing was adopted, and in these cases 1,000 pickets is not a convenient expression of area for comparing yields. The phrase, 'bags per 1,000 pickets' is customarily abbreviated into, 'bags per 1,000'. Some planters calculate yields in 'bags per 1,000 full-bearing trees', on the grounds that blank spaces and immature trees cannot contribute any yield and that the area they occupy should not be included. They ignore the fact that 'blanks' and 'supplies' demand expenditure on cultivation. Every estate contains same 'blanks' and 'supplies', but the number of such unproductive pickets varies to an extent which renders the term '1,000 full-bearing trees' meaningless as a unit of area. The Agricultural Bank of Trinidad and Tobago unfortunately regarded '1,000 full-bearing trees' as synonymous with '1,000 pickets' and in consequence overestimated yields per acre and the value of each estate. In the present articles yields are expressed in bags per 1,000 pickets in deference to local usage, but the calculation of yields on an acreage basis is much to be preferred.)

Rabot. = Literally a 'plane' (French). A wooden rake used for spreading and heaping cacao beans.

Rod. = A labourer employed in picking cacao, named after the long bamboo rod to which the picking knife is attached.

Supply. = A young plant used to replace another. 'Estate supplies' consist of materials purchased for the use of the estate.

LEPIDOPTEROUS PESTS OF THE SOUR-SOP IN TRINIDAD.

(1) *Cerconota* (*Stenoma*) *anonella* Sepp.

By R. G. Fennah.
Department of Entomology.

Introduction.

Although the Sour-Sop (*Anona muricata* L.) is a common garden plant in Trinidad, the fruit appears on the local market in negligible quantity. This is mainly because the developing fruit is attacked by insects, among which three species are of chief importance: *Cerconota* (*Stenoma*) *anonella* Sepp. (Stenomidae), *Thecla ortygnus* Cramer (Lycaenidae), and *Bephrata maculicollis* Cam. (Eurytomidae). Species of *Bephrata* are widely distributed through the Caribbean area and, as larvae, infest seeds of anonaceous fruits. In the case of the Sour-sop they cause damage to the flesh when boring from the seed to the exterior. The lepidopterous pests are somewhat more restricted in their distribution than the Eurytomid and, in Trinidad at least, the depredations of *C. anonella* are far more serious. *Cerconota* (*Stenoma*) *anonella* Sepp. is recorded as occurring in Brazil, Honduras, Panama and Trinidad, B.W.I. From time to time Sour-sop trees have been inspected by the writer in the islands of St. Lucia and Montserrat but so far no signs of the presence of this moth have been observed, and no records of its occurrence in any of the islands north of Trinidad have been seen. This species has been recorded as attacking Custard apple (*Anona reticulata* L.) (1) and Sour-sop (2) in Brazil, and the writer has reared it from these hosts in Trinidad. In addition it has been observed to attack cherimoyer (*Anona cherimolia* Mill.). Unstated species of Stenoma have been noted on guava (*Psidium guajava* Radd.), *Inga setifera* DC. and *Inga ingoides* W. in Trinidad (3), and on *Inga vera* W. in Puerto Rico (4).

Status and Damage.

The incidence of the pest is very high, and it is common to find on a tree every fruit above three inches in length attacked. So far very few cases have been observed where more than 50 per cent. of the mature fruit were free from blemish caused by this insect.

The damage to the fruit caused by the larva may be superficial or complete. In the former type blackened depressions in the form of shallow tunnels of about 7 mm. diameter are to be observed on the outside of the fruit, situated between the bases of the areolar spines. When the fruit is cut open, these tunnels are found to end blindly in the cells which form the tough outer covering of the tissues in which the seeds are embedded. In the second type blackened fragments of vegetable matter, loosely interwoven with threads of silk, fill depressions on the surface, and round such agglomerations the epidermis of the fruit is frequently of a uniform yellow colour, in contrast to the normal green. When this material is removed from the surface a tunnel is revealed, in this case blocked at its outer end by further fragmentary material which is usually sodden with moisture. Inside the fruit the tunnel is continued, and is confined to the pulp between the outer covering and the elongated receptacle which forms the core. The tunnel walls are black and the tissues immediately behind them are brown. A single tunnel is approximately two inches in length, but frequently large cavities are formed, partly filled with sodden putrefying tissue round which necrosis of a relatively considerable volume of the pulp takes place. In the blackened decaying material an association of saprophagous insects may regularly be found, including fly maggots and beetles in the adult and larval state (spp. of *Atheta* and *Coproporus*). In the case of the flies the eggs are laid in the mass at the mouth of the tunnel, and the larvae work their way to the moister parts inside. The beetles appear to oviposit anywhere in the mass, as the adults themselves penetrate to the interior along the tunnels made by the Stenomid. On fruit in which internal injury has reached an advanced stage the opening to the exterior of certain tunnels is protected by a brownish cap, which is formed by the Stenomid larva over the exit hole. (Fig. 4.)

In many cases the fruit is mis-shapen and the most depressed point on the surface often contains larval tunnel. The modification in shape is mainly due to the destruction of a group of cells at the point of entry of the insect, leading to retardation in growth of the affected area. The resulting distortion frequently takes the form of a twist of the axis into a crescentic shape, sometimes accompanied by deep grooving parallel with the axial line (Fig. 1). Twisting of fruit in the early stages of growth is common even when no attack has occurred, but no grooving is present.

Life History.

The Egg.

The egg when first laid is pale green and translucent, and is from .5 to .6 mm. long and .3 mm. broad at its widest part. It is normally deposited in a crevice on the surface of the fruit, though eggs are occasionally seen plastered to the curved spines. Viewed from above it is bluntly oval in outline; from the side the upper surface appears somewhat depressed and the lower is flattened against the substratum. The surface of the egg is marked with parallel ridges, about eleven being observable from any one viewpoint. Between these are numerous transverse ridges, dividing the surface into small sub-equal trapezoidal areas with a depression in the centre. The surface is highly polished, and with a low degree of magnification has the appearance of being facetted,

During development of the larva inside, the colour of the egg changes to a light brown, and after hatching has occurred the empty chorion is white and translucent. The incubation period is between two and three days. At the end of this time the larva emerges through an irregular hole on the upper side near one end.

THE LARVA.

After hatching, the larva seeks a protected spot, such as a crevice, and passes a few threads across the exposed side by a waving motion of the fore-end of its body. It then commences to bore its way inwards. Particles are bitten out and are placed on the strands of the web, or at the side of the crevice, where they rapidly change to a brown colour.

As the larva disappears this material assumes the form of a heap, and subsequently darkens, appearing somewhat similar to crumbs of soil. This deposit is augmented later by faecal pellets thrust out from the tunnel. In the field no case has been noted by the writer where fruit of more than six inches in length has contained newly-hatched larvae. As it appeared possible that young larvae would not bore into fruit after it had reached a certain size, some attention was given to this point. Three newly-hatched larvae were transferred to a half-grown fruit. This they proceeded to traverse in approximately a spiral course, moving fairly rapidly. Whenever they encountered crevices they investigated them, but, as long as observed, did not attempt to make their way in. Finally an artificial injury was made by gouging, this being about six mm. square tapering to a point just below the outer covering of the fruit. In turn all three larvae, wandering over the surface, reached and entered this depression, and, while investigating it, turned back whenever they reached its edge, thus apparently selecting the spot by an avoiding reaction whenever external tissue was encountered. The boring inwards which followed was carried out in the normal manner. About two hours later the exposed tissue had dried considerably, and had turned brown. A further larva was then placed on the fruit, and on reaching the spot did not appear to be attracted, and continued to wander over the surface of the fruit for as long as observation of its movements was maintaind. It was found subsequently that only the larvae which had been seen to enter had penetrated the fruit; the three tunnels led from the observed initial points of entry, and one larva was in each tunnel. On several occasions fruit about six inches long has been found with superficial damage, and, rarely, young larvae have been found in the shallow borings, which do not penetrate to the pulp. The facts that these tunnels are usually untenanted, and that similar shallow borings are very uncommon on young fruit lend some support to the hypothesis based on field evidence that fruit is practically safe from attack when it has reached a length of about six inches.

While feeding, the larva periodically clears its tunnel by pushing excreta towards the entrance. The orifice of the boring is enlarged after the larva has entered the fruit, but normally does not become exposed. A screen of faecal pellets is added to the particles of fruit initially placed on the web by the larva. These pellets are dark brown or black when dry, but reddish-brown when moist; a quantity of moist excrement is usually to be found beneath the exterior mass.

At all stages of growth the larva is extremely active when disturbed: when touched or removed from a tunnel it twists violently from side to side, and when released sets off rapidly in search of shelter. If the covering at the mouth of the tunnel is brushed aside and the entrance exposed, the larva, after a momentary retreat, turns round and quickly stretches strands of silk across the opening. Its method of weaving may not be entirely haphazard, as in the cases observed a definite order was seen to be followed. At first a number of threads were laid in a horizontal direction, then others were added at a low angle to these, and finally a series was carried across in a vertical direction. The opening was then screened further by the application of faeces to the strands.

Moulting takes place in the tunnels, and the exuviae are pushed towards the exterior when the tunnel is cleared. From collected head-capsules there appear to be five ecdyses and this number agrees with that estimated by Dyar's law. After the first three the larva assumes a dark reddish hue. The colour resides in the internal tissues and the appearance of the larva changes rapidly to pink if it is placed in 70 per cent. alcohol. The epidermis itself is transparent and glossy. When about to pupate the larva is of a reddish-purple colour, this being especially pronounced behind the prothorax. The head capsule and the dorsal plate on the prothorax are dark brown, and the area around the base of each seta on the body is pigmented with black. When fully grown the larva is about 16 mm. long and just over 3 mm. in diameter. The total period spent in the larval stage is between 11 and 12 days.

Mortality of larvae appears to be at its highest after they have hatched and before they enter the fruit. As far as observation goes the rate of mortality inside the fruit is very low.

THE PUPA.

When about to pupate the larva bores to the surface and pierces the outer covering of the fruit. The opening so made is covered with a silken cap to which are attached fragments of vegetable matter similar to those placed on the web by the newly hatched larva just after making its entry. This cap is roughly rectangular in side view, and projects about 7 mm. from the surface. It is bilaterally compressed and the sides meet along a narrow edge. A thin but tough cocoon, yellowish to grey in colour, is woven, and its cavity is prolonged to the exterior of the fruit by means of a short tunnel lined with silk, which, in turn, passes into the cap projecting from the surface.

FIG. 1.—Sour-sop showing tunnels of *C. anonella,* after removal of débris.

FIG. 2.—A simple method of applying insecticide

FIG. 3.—Tree with fruit protected by bags of waxed paper.

FIG. 4.—Portion of fruit, showing (1) cavity filled with excreta (2) pupa in cocoon (cut open), and cap made of silk and fragments of fruit.

FIG. 5.—*C. anonella* resting on fruit.

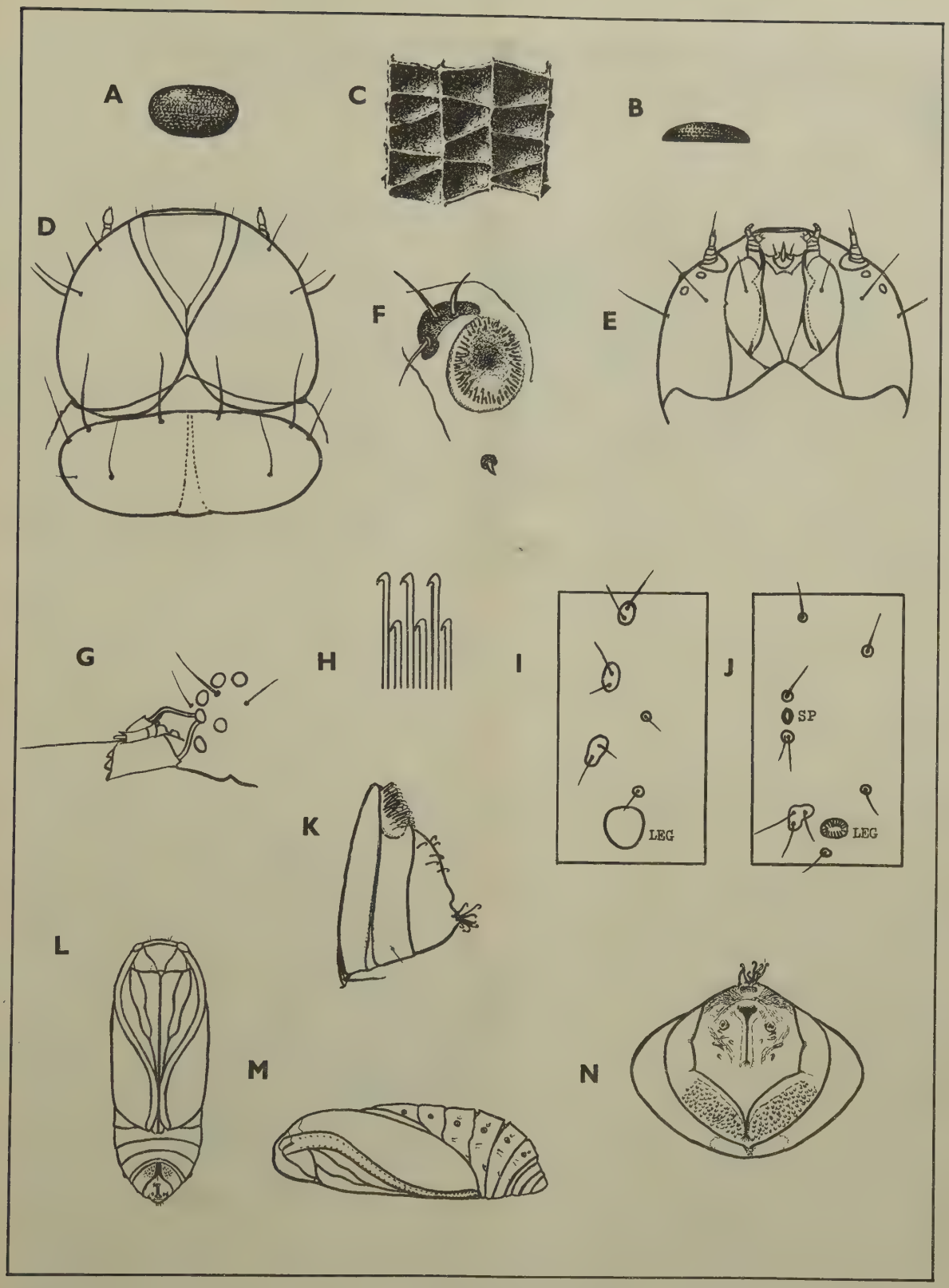

FIG. 6.—EGG. A. seen from above. B. seen from side after being laid. C. surface, greatly enlarged. LARVA. D. head, dorsal aspect. E. head, ventral aspect. F. pro-leg. G. ocelli and antenna. H. crochets of proleg. I. setal map, 2nd thoracic segt. J. setal map, 5th abdominal segt. PUPA. K. posterior end, side view. L. ventral view. M. side view. N. posterior end, ventral view.

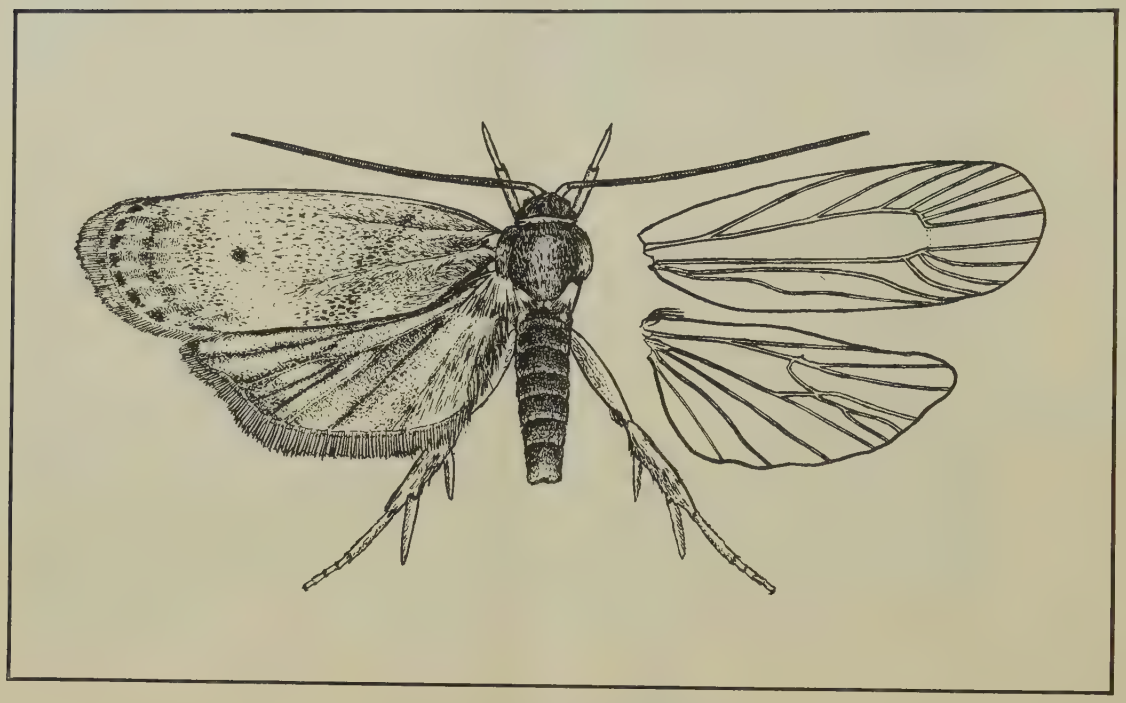

FIG. 7. *Cerconota* (*Stenoma*) *anonella* Sepp.

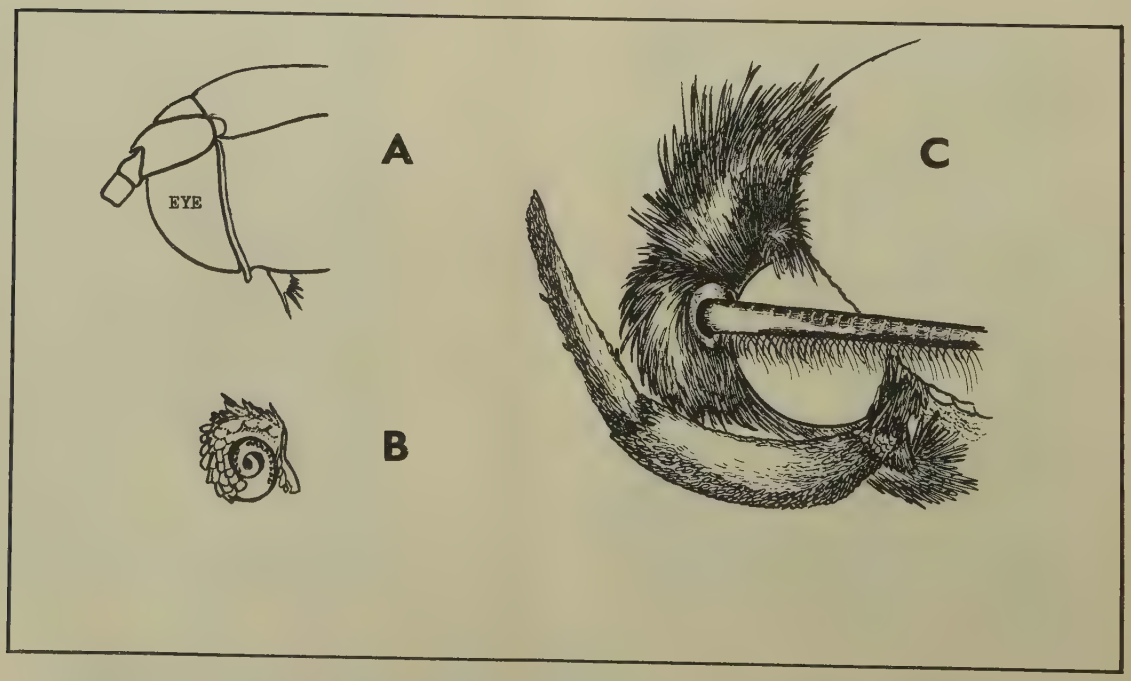

FIG. 8. A. half head, with scales removed, seen from front. B. tongue, seen from side. C. head, side view, eye unshaded.

The pupa is formed in the tunnel near the exit, with the anterior end directed outwards. It is about 7.0 mm. long and 2.7 mm. at its greatest diameter, and is of a reddish-brown colour and has a burnished appearance. The pupal stage occupies 11 or 12 days.

THE ADULT.

The adult moth is 7.0 to 7.5 mm. long, and has a wing expanse of just over 19 mm. It is uniformly of a pale straw colour, with the exception of the upper surface of the fore-wings which bear a small dark spot half-way between the fore and hind margin, approximately two-thirds of the length of the wing from the body. Between this and the edge of the wing is a thin crescent of brown scales, while between the veins at the margin occur spots of dark brown. An oblique line of brown scales traverses the wing not far from its base. These markings may be obscured on specimens on which the wing-scales have been disturbed.

In the field the moth appears to be mainly nocturnal in habits, though on one occasion a specimen was seen fluttering among Sour-sop foliage in the middle of the day. In the laboratory the moths are for the most part quiescent in the daytime and remain for long periods with the antennae curved backwards along the wings (Fig. 5). Oviposition occasionally took place diurnally, but no case was observed in the field.

The flight is quick and is usually made in darts over short distances at a time. If disturbed while resting on a Sour-sop fruit, female moths often run rapidly for a few inches instead of taking to flight. In other situations, however, resort to flight occurs at the first alarm.

It has been observed that the moth completes its development while the fruit is still hanging on the tree. Even if the fruit drops when the larva is little more than half grown the insect is usually able to complete its development before the fruit has dried out. So far no resting phase either in the form of delayed hatching of the egg, prolonged development of the larva, or abnormal length of pupation has been noted. No parasites of any stage of the insect have been observed in Trinidad, nor have there been any indications of their presence. Judging from the quantity of material collected in the field and reared to maturity in the laboratory, it is safe to assume that if parasites of *C. anonella* exist in the island, their incidence was negligible during the period of investigation.

OVIPOSITION.

Soon after emerging the female is fertilized, and in the laboratory has been observed to lay eggs after two days. When about to oviposit, the moth alights on a fruit and works its way across the surface, scrambling between the projecting spines. The antennae are held out and maintain a thrashing movement up and down. At a suitable spot the insect bends the apex of the abdomen downwards until it is practically touching the fruit, swiftly protrudes the ovipositor, and deposits an egg. This done, it immediately moves away and may lay a few more in a similar manner, after which it remains motionless in the resting position for an indefinite period. In some cases a prolonged pause occurs after the deposition of each egg.

In the case of Sour-sop, eggs are invariably laid on the fruits. On being deposited, the egg, which in the oviduct is a spheroid with blunt ends, assumes a somewhat flattened form. Its green colour renders it difficult to distinguish from the rough surface of the fruit, especially as the latter is closely patterned with pale green spots, each of which is rather smaller than the egg. The eggs are laid singly, or rarely in a group of two, but a single fruit may have over a dozen affixed to it at different points. The writer has so far not reared more than ten adults from a single fruit. On the whole, the lower end of the fruit appears to be utilized for oviposition more frequently than any other part. The maximum number of eggs seen to be deposited by a single female over a period of three days was 14, but it is likely that this number is greatly exceeded in natural conditions. In the eight ovarioles of a female dissected a day after emerging from the pupa 264 eggs were counted, of which not more than 20 appeared to be full sized.

Methods of Control.

No eggs have been found on fruit until it has reached a size at which the spines have separated from each other, while, as stated above, after a certain amount of growth has taken place the fruit may be considered immune from attack. The period of maximum susceptibility to attack is while the fruit is between one and six inches in length, and control may most effectively be aimed at preventing infestation between these stages of growth.

Two protective methods have been tested. The first is that of covering the fruit with bags of cloth or waxed paper (Fig. 3). If applied sufficiently early this method has been found to give complete protection. If bagging is delayed until the fruit is two inches long the chance of infestation is increased, and eggs are frequently present in such cases at the time of affixing the covers. Both cotton and paper bags waxed by dipping into melted paraffin wax are relatively durable even under wet conditions. If waxed paper is used a short longitudinal incision should be made at the lowest point of the bag through which any rain water which may run into the bag can drip away. This incision remains too narrow to permit the entry of the female. In the case of cotton bags the material should be sufficiently closely woven to prevent the entry of the newly hatched larva, since it has been found that in the laboratory females will oviposit on moist cloth or blotting-paper which had previously been rubbed against the outside of a Sour-sop.

The chief disadvantage of this method is that it is accompanied by a certain amount of fruit dropping. A number of small fruit, even if not

bagged, drop before they have developed, so that the amount of dropping to be ascribed to this treatment is not easy to estimate. Such loss, however, is made good by the quantity of fruit which reaches maturity in a sound condition.

The second method, which has so far given good results, consists in the application to the fruit of a two per cent. suspension of lead arsenate with casein added. To ensure an even covering the most satisfactory method of application is by means of a small atomising sprayer. In the absence of this quite a good cover can be obtained by the method illustrated in Fig. 2. A small vessel, of a size sufficient to accommodate the young fruit, is filled with the liquid, and pushed a few times over the fruit from below. It is important that the fruit be completely immersed, and repeated immersion is advised to fill up gaps caused by the presence of air trapped below the spines. As the fruit grows the cover becomes broken, and two more applications should be made. Before this becomes ineffective the fruit is usually large enough to be safe from infestation. When the fruit has reached maturity the residues are very small, and in any case, when Sour-sop is used, the outer covering is discarded.

Costs.

For the average tree usually not more than 15 bags will be needed, as the number of fruit in the susceptible stage is generally less than this, and bags can constantly be transferred from developed to young fruit. A set of cotton bags made locally and lightly waxed should not cost more than 2*s.* 6*d.*, and should last not less than two years. Paper bags dipped in paraffin wax are durable but are somewhat apt to be torn when the top is drawn tight above the fruit. Changing the bags in practically all cases would be carried out by the owner, and could be done conveniently when ripe fruit is picked. The lead arsenate method is extremely cheap, as little more than two fluid ounces of the two per cent. suspension is needed for each tree at each application. Where casein is not available other adhesives may be tried, such as gelatin, gum or starch. They should be added to the liquid shortly before it is applied.

No comparison of the two methods has been attempted on a quantitative basis. Both are effective against *C. anonella.* In one case dropping of fruit—which inevitably occurs to some extent—is increased, but this is more than counterbalanced by the increase in yield of marketable fruit. The second method, unlike the first, cannot be regarded as affording simultaneous protection against *Bephrata maculicollis,* so that some loss is liable to be suffered from this source which might offset any advantage accruing from lesser dropping of fruit. The risk of damage by the Eurytomid is difficult to assess owing to the fact that its incidence varies greatly from tree to tree, and between different periods of the year.

References.

1. Pinto da Fonseca, J.—*Arch. Inst. Biol.*, pp. 263-289. S. Paulo, 1934.
2. De Azevedo, A.—*Correio-agric.*, i, No. 3. pp. 59-60. Bahia, March, 1923.
3. U.S. Dept. of Agric. *B.P.Q., S.R.A.*, No. 116. Washington, Dec., 1933.
4. *Journ. Agric. Univ., Puerto Rico,* Vol. XX, No. 1, Jan., 1936, p. 498. Rio Piedras.

EFFECT OF ARTIFICIAL MANURES ON CROP QUALITY.

A recent paper published in the *Biochemical Journal,* XXX, 12, p. 2307, by J.B.H. Ijdo, of the University of Utrecht, Holland, describes interesting experiments on the influence of inorganic manures on the contents of the anti-scorbutic Vitamin C and of carotene (growth promoting Vitamin A) of spinach, grown in sand and soil cultures. The vitamins in the mature crop were determined by standard chemical methods. The results obtained demonstrate that the amounts of these two vitamins produced in the test plant largely depend on the amounts of nitrogen and potassium added to the cultures. Increase in nitrogen resulted in greater Vitamin C and carotene contents, whilst increase in potassium produced an increase in carotene but a decrease in Vitamin C. The influence of calcium, magnesium and phosphate was found to be negligible. It is suggested that there exist direct relationships between photosynthesis and Vitamin C content, and between chlorophyll production and carotene content. This suggestion is supported by the experimental evidence obtained. At a low nitrogen level, the chlorophyll content of potassium-deficient plants was found to be much higher than that of plants abundantly supplied with potassium, but at a high nitrogen level, this difference did not exist. Thus, nitrogen and potassium appear to be closely inter-related physiologically; potassium deficiency exerts similar effects as nitrogen excess, and *vice versa.*

The results described above for spinach apparently were not obtained by C. R. Fellars and R. E. Young, who examined the effect of nitrogenous and potassic manures on the vitamin content of asparagus (*Proc. Amer. Soc. Hort. Sci.*, 1934, 31, p. 145). Variations in the amount of nitrogen and potassium did not affect the contents of Vitamin C or of Vitamin A (carotene) in their experiments on asparagus plants.

The great importance of the question of quality of food crops (which is at least partly decided by their vitamin contents), as affected by different systems of manuring would seem to necessitate a continuation of the work and its extension to other crops.

RECENT INVESTIGATIONS ON SUGAR-CANE AND SUGAR-CANE SOILS IN ANTIGUA.

II.—MANURIAL EXPERIMENTS REAPED IN 1936.—*Continued.*

By P. E. Turner, F. H. S. Warneford and C. F. Charter.

Experiments with Inorganic Manures.

Sulphate of Ammonia.

Method of Application.

Quintus (6) definitely recommends that sulphate of ammonia should be applied to plant canes in manure holes and not scattered in the furrows because the subsurface soil remains moist for a longer period than the surface soil and nitrification ceases when the soil has dried out. Earle (7) also considers that sulphate of ammonia should be covered with earth and that it is wasteful to apply this manure to the surface of the soil.

Burying a manure in specially prepared holes adds to the cost and also slows down the rate of its application. A comparison has therefore been made of the effects on yield of plant canes of a dressing of sulphate of ammonia when scattered on the surface of the soil, and when buried, under conditions which obtain in Antigua.

The experiment was laid down on a lightly calcareous area of Bendall's clay. The manure was applied during the middle of the dry season. The rainfall during the two months before and after its application was as follows:—

February—1.89 ins.	April—2.45 ins.
March—1.18 ins.	May—3.14 ins.

The yield data are recorded in Table XII.

Table XII.—Effect on yield of plant canes of method of application of sulphate of ammonia on a lightly calcareous soil.

Soil type: Bendall's clay (0.4 per cent. $CaCO_3$).
Estate: Greencastle.
Variety: B. 2935. *Manured*: 10/4/35.
Planted: 30/1/35. *Reaped*: 12/3/36.
Rainfall (13½ months): 58 inches.
Layout: Eight randomised blocks.
Plot size: 1/240 acre.

S/A per acre.	Method of application around stool.	Yield of plants, tons per acre.	Gain tons per acre.
Nil.	—	40.79	—
5 cwts.	Buried to depth of 8 inches	42.92	2.13
5 cwts.	On surface	44.08	3.29

A somewhat larger gain in yield of plant canes was obtained by spreading the sulphate of ammonia on the surface of the soil around the stool than by burying the manure to a depth of eight inches. It is of interest that in Trinidad (8, 9) no definite gain has been found to result from covering sulphate of ammonia with earth whether the dressing is applied in the dry season or wet season.

The average immediate gain in yield arising from treatment with five cwts. of sulphate of ammonia was 2.71 tons of cane. The dressings were applied ten weeks after planting. It is possible that a larger gain would have been obtained if this interval had been shorter. It is probable that a smaller dressing would have given an equally large gain.

Immediate and Residual Effects of Sulphate of Ammonia on Yield.

Evidence was obtained in the preliminary series of experiments to the effect that on certain lightly calcareous areas of the island definite financial benefit could be derived from appropriate use of sulphate of ammonia, whereas the presence of calcium carbonate in the soil in excess could adversely limit or even completely remove the gain in yield to which this manure normally gives rise (2). A further series of experiments with sulphate of ammonia has now been harvested on a range of soils containing from 0.1 per cent. to 50 per cent. calcium carbonate.

Lightly calcareous soils.

The experiment on a lightly calcareous soil with early and late applications of sulphate of ammonia to plant canes at Betty's Hope Estate has been reaped for a second time to measure the residual effects of the various dressings on the yield of the first ratoons. The information obtained is set out in Table XIII.

The experimental area was lightly dressed with trash as plant canes. The soil contains 1.6 per cent. calcium carbonate.

The late dressing of two cwts. of sulphate of ammonia, which was applied after the end of the dry season, gave rise to a gain in yield of 3.00 tons of plant canes. The dressing had an equally large residual effect on the first ratoons. On this lightly calcareous soil sulphate of ammonia behaved normally, in that it gave rise to significant immediate and residual gains in yield and in that the total gain of 6.02 tons of plant canes and first ratoons is characteristic of the beneficial effect to which two cwts. of the manure can give rise. In a wetter climate, such as that of Trinidad, the immediate gain would have been larger and the residual gain smaller, but the total gain would have been approximately of the same size. There is little to choose between the effects (to date) of the late dressings of two cwts. and four cwts. to the acre, but the possibility exists that the residual effect of the heavier dressing on the second ratoons will be the larger.

The inclusion of an additional and earlier (dry-season) dressing to the acre of two cwts. of sulphate of ammonia to the plant canes led to complete loss of the immediate gains to which the late dressings gave rise and significantly reduced the

Table XIII.—Immediate and residual effects of sulphate of ammonia on yield on a lightly calcareous soil.

Soil type: Elliot's sandy clay (1.6 per cent. $CaCO_3$). *Estate*: Betty's Hope.
Planted: 22/12/33. *Variety*: Ba. 11569.
Reaped: 16/3/35 (as plants), 25/4/36 as first ratoons.
Rainfall: 42 inches as plants (14¾ months), 47 inches as first ratoons (13¼ months).
Layout: Seven randomised blocks.

Yields are expressed as tons cane per acre.

S/A per acre (1934).		Plants (1935).		1st Ratoons (1936).		Total gain to date.
March	Aug.-Sept.	Yield.	Gain.	Yield.	Gain.	
Nil	Nil	29.40	—	18.35	—	—
Nil	2 cwts.	32.42	+3.02	21.35	+3.00	+6.02
Nil	4 cwts.	32.31	+2.91	22.08	+3.73	+6.64
2 cwts.	2 cwts.	28.78	−0.62	19.85	+1.50	+0.88
2 cwts.	4 cwts.	29.90	+0.50	21.28	+2.93	+3.43

average residual gain. There is reason to believe that this adverse effect of the earlier dressing is associated with lack of adequate available potash.

Yield data for the first crop of cane in another trial with sulphate of ammonia on a lightly calcareous soil are recorded in Table XIV.

Table XIV.—Effect on yield of plant canes of sulphate of ammonia on a lightly calcareous soil.

Soil type: Bendall's clay (0.4 per cent. $CaCO_3$).
Estate: Greencastle.
Variety: F.C. 916. *Manured*: 3/7/35.
Planted: 17/5/35. *Reaped*: 14/4/36.
Rainfall (11 months): 46 inches.
Layout: Randomised blocks. *Plot size*: 1/194 acre.

Sulphate of ammonia per acre.	Yield of plants* tons per acre.	Gain tons per acre.
Nil	21.46	—
4.3 cwts.	27.19	5.73

* Mean values for four replicates.

There is some evidence that the experimental area has been manured with filter-press mud in the past.

The dressing of 4.3 cwts. of sulphate of ammonia, which was applied some six weeks after planting, gave rise to a gain of 5.73 tons of plant canes. It is probable that a smaller dressing would have given rise to an equally large immediate gain.

So far sugar cane in Antigua has failed to give immediate response to sulphate of ammonia in only one of the experiments on lightly calcareous soils. This experiment was laid down on an area of Gunthorpe's clay which had not been under cultivation for many years. During this period it is probable that a store of available nitrogen had accumulated in the soil which was adequate for the needs of the first crop harvested.

In all, six experiments with sulphate of ammonia (four on plant canes and two on ratoons) have been harvested on lightly calcareous soils of the island. The results are summarised in Table XV. They suggest that satisfactory gains in yield of cane may be obtained by appropriate use of sulphate of ammonia on continuously cropped areas of Bendall's and Otto's clays, of Elliott's sandy clay and of Blubber Valley sandy loam, provided that less than two per cent. calcium carbonate is present in the soil. Further experiments on the lightly calcareous soils are necessary, however, if the optimum size of dressing of sulphate of ammonia to plant canes and ratoons is to be accurately determined.

The average rainfall during the life of the plant canes on the lightly calcareous experimental areas was 49 inches. The average rainfall during the life of the ratoon canes was 39 inches.

Calcareous soils.

Sixteen experiments with sulphate of ammonia on plant canes and three experiments on ratoon canes have now been reaped on a range of soils containing from 2.2 to 58 per cent. of calcium carbonate. Of these experiments ten were laid down on areas of Fitches clay, eight on areas of Gunthorpe's clay and one on an area of Tomlinson's clay. The yield data for the 19 experiments are summarised in Table XVI.

Plant Canes.

Small losses and gains in yield occur with equal frequency in the experiments with plant canes on calcareous soils as a result of treatment with sulphate of ammonia. The maximum recorded loss of 1.06 tons resulted from a dressing of 2 cwts. of sulphate of ammonia to a highly calcareous Fitches clay. In one case only was a significant increase in yield obtained. This experiment was laid down on a Gunthorpe's clay containing 2.2 per cent. calcium carbonate. The dressing of sulphate of ammonia was 3 cwts., and the gain was 1.90 tons.

Table XV.—Summary of results of 1935-36 experiments on soils containing less than 2 per cent. calcium carbonate. Immediate effects of sulphate of ammonia on yield of cane.

Yields are expressed as tons cane per acre.

Soil type.	$CaCO_3$ (per cent.) in topsoil.	Previous treatment of experimental area.	Rainfall during life of crop.	Variety of cane.	Yield of cane.		Immediate gain from S/A.
					No S/A.	S/A.	
PLANT CANES:							
Bendall's clay	0.4	Manured with scum cake	58 ins.	B. 2935	40.79	44.08	+3.29
do.	0 4	do.	46 ins.	F.C. 916	21.46	27.19	+5.73
Elliot's sandy clay	1.6	Not regularly penmanured	42 ins.	Ba. 11569	29.40	32.42	+3.02*
Gunthorpe's clay	0.1	Not under cultivation	55 ins.	B.H. 10(12)	35.62	35.88	+0.26
RATOON CANES:							
Otto's clay	1.1	Regularly penmanured	39 ins.	Ba. 11569	21.03	28.00	+6.97
Blubber Valley sandy loam	Nil	do.	38 ins.	B.H. 10(12)	10.33	17.08	+6.75

* The residual gain from a dressing of 2 cwts. of sulphate of ammonia has been measured in this experiment and found to be 3.00 tons of cane.

Table XVI.—Summary of results of 1935-36 experiments with sulphate of ammonia on soils containing more than 2 per cent. calcium carbonate.

Yields are expressed as tons cane per acre.

Soil type.	$CaCO_3$ (per cent.) in topsoil.	Previous treatment of experimental area.	Rainfall during life of crop.	Variety of cane.	Yield of cane		Average immediate gain from S/A
					No S/A.	S/A.	
PLANT CANES:							
Fitches clay	58	Regularly penmanured	50 ins.	Ba. 11569	29.76	30.17	+0.41
do.	50	do.	35 ,,	Ba. 11569	27.71	27.56	−0.15
do.	24	Not regularly penmanured	49 ,,	Ba. 11569	27.83	26.77	−1.06
do.	17	Regularly penmanured	53	B. 147	14.42	15.93	+1.51
do.	15	do.	61 ,,	B. 147	30.00	30.21	+0.21
do.	13	do.	38 ,,	B.H. 10(12)	26.21	25.89	−0.32
do.	8.6	Not regularly penmanured	36 ,,	S.C. 12/4	23.44	23.88	+0.44
Gunthorpe's clay	16	Regularly penmanured	40 ,,	B.H. 10(12)	21.71	21.06	−0.65
do.	12	Not regularly penmanured	48 ,,	B.H. 10(12)	33.18	32.99	−0.19
do.	11	do.	57 ,,	B.H. 10(12)	20.71	22.11	+1.40
do.	8.3	Regularly penmanured	39	Ba. 11569	36.70	37.83	+1.13
do.	6.4	Not regularly penmanured	45 ,,	B.H. 10(12)	21.70	22.29	+0.59
do.	5.5	do.	51 ,,	B.H. 10(12)	25.54	25.17	−0.37
do.	3.6	do.	49 ,,	B.H. 10(12)	20.20	19.68	−0.52
do.	2.2	do.	45 ,,	B.H. 10(12)	22.06	23.96	+1.90
Tomlinson's clay	2.2	do.	46 ,,	B.H. 10(12)	26.62	26.22	−0.40
RATOON CANES:							
Fitches clay	30	Regularly penmanured	43 ,,	B.H. 10(12)	14.65	17.33	+2.68
do.	19	do.	39 ,,	B.H. 10(12)	22.28	24.48	+2.20
do.	15	do.	50 ,,	B. 147	24.54	26.28	+1.74

The unsatisfactory response of the plant canes to sulphate of ammonia does not appear to be dependent on the previous manurial treatment of the soil, for the losses and gains occur indiscriminately on unpenmanured and regularly penmanured areas of Fitches clay and Gunthorpe's clay. It does not appear to depend on rainfall, for the average rainfall of 46 inches during the life of the plant canes on the calcareous experimental areas is almost identical with the corresponding figure of 49 inches for the lightly calcareous experimental areas.

The experiments with plant canes on the calcareous areas were laid down on Fitches, Gunthorpe's and Tomlinson's clays. The successful experiments on the lightly calcareous areas were laid down on Bendall's clay and Elliott's sandy clay. Apart from complications which may be introduced by differences in soil type it would seem from the data so far available that the presence in the soil of calcium carbonate in excess of two per cent. is the main factor associated with the failure of sulphate of ammonia to give rise to paying increase in yield.

Ratoon Canes.

In the three experiments with ratoon canes on areas of Fitches clay treatment with sulphate of ammonia led to gains in yield which can be established as statistically significant. The gains are small, however, and unimportant in comparison with those obtained on lightly calcareous areas of Otto's clay and Blubber Valley sandy loam (Table XV).

The average rainfall during the life of the ratoon canes on the calcareous experimental areas was 47 inches. The corresponding value for the ratoon canes on the lightly calcareous areas is only 39 inches.

Plant Canes and Ratoons.

In view of the failure of sulphate of ammonia to give paying immediate gains in yield of cane on calcareous soils it becomes of importance to determine whether the dressings have any residual effect on the following crop. Three of the preliminary experiments (2) on plant canes with sulphate of ammonia, which were situated in areas of low rainfall, were therefore continued to the ratoon stage, no manure being applied to the ratoons. Yield data for two of these experiments, laid down respectively on a Fitches clay and a Gunthorpe's clay, are set out in Table XVII.

The dressings of sulphate of ammonia to the plant canes in both experiments were applied after the end of the dry season. In both this manure had only very small residual effects on yield which are in no way comparable with the residual effects recorded in Table XIII for corresponding treatments on a lightly calcareous soil.

The yield data for the third experiment are summarised in Table XX.

General comments.

The presence of calcium carbonate in excess in the soil has been found in Trinidad to have an adverse effect on the gain in yield of plant canes and ratoons to which treatment with sulphate of ammonia can give rise. Under the conditions which obtain in Trinidad it has been shown (3) that the adverse effect can be counteracted by a dressing of readily available phosphate, although treatment with potash also may be necessary on potash-deficient soils. Preliminary measures of the response of plant canes to sulphate of ammonia, in the presence of phosphate and potash, on calcareous soils of Antigua are recorded in a later section of this paper.

Table XVII.—Immediate and residual effects on yield of sulphate of ammonia on calcareous soils.

Soil type:	Fitches clay, deep phase, (50 per cent. CaCO).	Gunthorpe's clay. (8.3 per cent. $CaCO_3$).
Estate:	Gaynors.	Cochranes.
Variety:	Ba. 11569.	Ba. 11569.
Planted:	8/2/34.	29/3/34.
Reaped:	16/4/35 (as plants), 13/4/36 (as 1st ratoons).	23/4/35 (as plants), 6/5/36 (as 1st ratoons).
Rainfall (as plants):	35 inches (14¼ months).	39 inches (12¾ months).
(as 1st ratoons):	39 inches (12 months).	39 inches (12½ months).
Layout:	Latin squares.	Latin squares.

Yields* are expressed as tons cane per acre.

S/A per acre in 1934.	Fitches Clay.				Gunthorpe's Clay.			
	Plants (1935).	1st R. (1936).	Total	Gain.	Plants (1935).	1st R. (1936).	Total.	Gain.
Nil	27.71	26.16	53.87	—	36.70	25.72	62.42	—
2 cwts.	—	—	—	—	38.32	25.91	64.23	1.81
4 cwts.	27.56	26.32	53.88	0.01	37.33	26.59	63.92	1.50

* Mean values for 12 replicates.

Sulphate of Ammonia *v.* Nitrate of Soda.

Immediate and Residual Effects on Yield.

It has been suggested that in general nitrates might prove a more suitable source of nitrogen than ammonium salts under Antiguan conditions, for nitrification is said to be tardy in highly alkaline soils and it has not been satisfactorily proved that the ammonium ion is directly available to sugar cane. Five experiments in which direct comparisons were made of the effects on yield of sulphate of ammonia and nitrate of soda were reaped in 1935. They gave rise to the conclusion that in the absence of excess calcium carbonate dressings of both manures can lead to large gains in yield of ratoon canes, but that in the presence of excess calcium carbonate both manures fail to give rise to immediate satisfactory results. Additional information concerning their relative merits has been obtained from experiments reaped in 1936.

Lightly calcareous soils.

Plant and Ratoon Canes.

The experiment on first ratoons with sulphate of ammonia and nitrate of soda, laid down on a lightly calcareous soil at La Roches Estate, has been harvested a second time to obtain a comparative measure of the residual effects of the two manures. The yield data are set out in Table XVIII.

Table XVIII.—Comparison of the immediate and residual effects on yield of ratoon canes of sulphate of ammonia and nitrate of soda on a lightly calcareous soil.

Soil type: Otto's clay (1.1 per cent. $CaCO_3$).
Estate: La Roches.
Variety: Ba.11569. *Manured*: 10/7/34.
Reaped: June 1934 (as plants), 21/5/35 as 1st ratoons, 4/4/36 as 2nd ratoons.
Rainfall: 39 inches as first ratoons (11½ months).
33 inches as second ratoons (10½ months).
Layout: Four 4×4 Latin squares.

Yields are expressed as tons cane per acre.

Nitrogen per acre in 1934.	1st R. (1935)		2nd R. (1936)		Total gain (to date).
	Yield.	Gain.	Yield.	Gain.	
Nil	21.03	—	11.97	—	—
60 lb. as S/A	28.00	6.97	13.24	1.27	8.24
60 lb. as N/S	27.28	6.25	12.65	0.68	6.93

The experimental area was dressed with 25 tons of pen manure to the acre as plant canes.

The average residual effect of nitrogen, although small, might be due to chance less than once in 20 times.

On this area of Otto's clay, which contains 1.1 per cent. calcium carbonate, 60 lb. of nitrogen as sulphate of ammonia gave rise to an increase in yield of 8.24 tons of cane, an amount which is comparable with the gain to which a dressing of this size normally gives rise in wet climates, such as that of Trinidad. The total gain from the equivalent dressing of nitrate of soda is somewhat smaller, but the difference in favour of sulphate of ammonia cannot be established as statistically significant.

Calcareous soils.

Plant Canes.

The earlier experiments on calcareous soils to compare the effects of sulphate of ammonia and nitrate of soda on yield of plant canes were laid down on Fitches and Tomlinson's clays. Data are now available for an area of Gunthorpe's clay which contains 3.6 per cent. calcium carbonate (Table XIX).

Table XIX.—Comparison of the effects on yield of plant canes of sulphate of ammonia and nitrate of soda on a calcareous soil.

Soil type: Gunthorpe's clay (3.6 per cent. $CaCO_3$).
Estate: Parham New Work.
Variety: B.H. 10(12). *Manured*: 3/9/35.
Planted: 11/5/35. *Reaped*: 14/6/36.
Rainfall (13 months): 49 inches.
Layout: Two 5×5 Latin squares.

Yield of plant canes in tons per acre.

Nitrogen per acre.	Kind of Nitrogen.		Average yield.
	Sulphate of ammonia.	Nitrate of soda.	
Nil.	20.20		20.20
45 lb.	19.53	20.01	19.77
90 lb.	19.83	20.52	20.18

On this calcareous soil both sulphate of ammonia and nitrate of soda failed to increase the yield of the plant canes. The manures were applied after the end of the dry season following planting.

Plant Canes and Ratoons.

A comparative measure of the immediate and residual effects of sulphate of ammonia and nitrate of soda on a highly calcareous soil are recorded in Table XX.

Table XX.—Comparison of the immediate and residual effects on yield of sulphate of ammonia and nitrate of soda on a highly calcareous soil.

Soil type: Fitches clay (24 per cent. $CaCO_3$).
Estate: Parham Lodge.
Variety: Ba.11569. *Planted*: 29/12/33.
Reaped: 27/3/35 (as plants), 12/4/36 as first ratoons.
Rainfall: 49 inches as plants (15 months),
37 inches as first ratoons (12½ months).
Layout: Two 5×5 Latin squares.

Yields are expressed as tons cane per acre.

Manures per acre (1934).	Plants (1935).		1st Ratoons. (1936).		Total loss (to date).
	Yield.	Loss.	Yield.	Loss.	
Nil	27.83	—	16.73	—	—
42 lb. N as S/A	26.80	1.03	15.42	1.31	2.34
84 lb. N as S/A	26.74	1.09	15.40	1.33	2.42
42 lb. N as N/S	25.85	1.98	14.81	1.92	3.90
84 lb. N as N/S	26.89	0.94	15.20	1.53	2.47

The manures were applied to the plant canes after the end of the dry season.

The dressings of sulphate of ammonia and nitrate of soda led not only to immediate losses in yield of plant canes but also to residual losses in yield of ratoons. The average total loss resulting from treatment with nitrogen can be shown to be statistically significant.

Conclusion.

It would definitely appear that nitrate of soda is not superior to sulphate of ammonia as a source of nitrogen for sugar cane under the conditions which obtain in Antigua, and that the failure of sulphate of ammonia on the calcareous soils cannot be ascribed to tardy nitrification of the ammonium ion.

Sulphate of Ammonia with Phosphate and Potash.

Immediate Effect on Yield of Plant Canes.

A number of exploratory experiments which include early or late dressings of inorganic phosphate and potash, in addition to nitrogen, were harvested as plant canes in 1936. They were laid down on lightly calcareous areas of Bendall's and Otto's clays and on calcareous areas of Fitches and Gunthorpe's clays.

Lightly calcareous soils.

In one of the experiments on Bendall's clay a measure was obtained of the effects on yield of the variety B.H. 10(12) of dressings to the acre of two cwts. of sulphate of ammonia, two cwts. of superphosphate and two cwts. of sulphate of potash. The manures were applied alone, and in all possible combinations, some three months after planting. The layout of the experiment was in the form of six randomised blocks of eight treatments. As a matter of interest two of the blocks were irrigated during the dry months of 1935, a total of 8.4 inches of water being added over the period April to September. The yield data are summarised in Table XXI.

There is some evidence that in the past the experimental area had been dressed with filter-press mud, which contains nitrogen and phosphate in fair quantity. Nevertheless, the treatments with inorganic nitrogen and phosphate gave rise to significant average gains in yield to the acre of 3.13 tons and 2.70 tons of plant canes, respectively. Treatment with potash gave rise to an average gain in yield of 4.36 tons of cane which might be due to chance less than once in 100 times. On this lightly calcareous soil no interaction obtained between the nitrogen, phosphate and potash. The gain from each manure was independent of the presence or absence of the other manures.

Although the experiment was laid down on a high-yielding area, the average gain in yield of plant canes from the complete inorganic manure amounted to 11.35 tons of cane, an immediate gain which is much larger than any so far recorded for pen manure.

Table XXI.—Effect of treatment with nitrogen, phosphate and potash on yield of plant canes on a lightly calcareous soil.

Soil type: Bendall's clay (0.4 per cent. $CaCO_3$).
Estate: Greencastle.
Variety: B.H. 10(12). *Manured*: 18/4/35.
Planted: Jan. 1935. *Reaped*: 10/3/36.
Rainfall (14 months): 55 inches.
Layout: Six randomised blocks of 8 treatments.
Plot size: 1/484 acre.

Manurial treatment per acre.	Yield of Plant canes (tons per acre).		
	Irrigated blocks.	Unirrigated blocks.	All blocks.
Nil.	45.27	38.57	40.80
Nitrogen only	46.78	41.54	43.29
Phosphate only	50.02	38.68	42.46
Nitrogen, phosphate....	52.72	39.43	43.86
Potash only	50.45	40.08	43.54
Nitrogen, potash	54.99	41.65	46.10
Phosphate, potash	58.02	40.08	46.06
Nitrogen, phosphate, potash	57.48	49.48	52.15
Average gain from:			
Nitrogen	2.05	3.68	3.13
Phosphate	5.19	1.46	2.70
Potash	6.54	3.26	4.36
Nitrogen, phosphate and potash	12.21	10.91	11.35

The average yield on the irrigated blocks was 51.97 tons of cane, while that on the unirrigated blocks was 41.19 tons, the difference being 10.78 tons. The gain in yield of 12.21 tons obtained on the irrigated blocks from the complete inorganic manure was only 1.30 tons larger than the corresponding gain of 10.91 tons obtained on the unirrigated blocks, however.

The topsoil of the experimental area contains 0.4 per cent. calcium carbonate.

The yield data for another experiment on plant canes with a complete inorganic manure, laid down on an adjacent area of Bendall's clay, are recorded in Table XXII. In this case the variety used was B. 726. The manure, which contained equal proportions of sulphate of ammonia, superphosphate and sulphate of potash gave rise to an immediate gain in yield of 6.59 tons of cane to the acre.

In a third experiment on a lightly calcareous and comparatively low-yielding area of Otto's clay a dressing of nitrogen, phosphate and potash failed to give rise to gain in yield of plant canes. In this case application of the manure was delayed until after the end of the dry season, *i.e.*, approximately five and a half months after planting. It has been found in Trinidad that plant canes rarely respond to such late treatment with phosphate and potash even when conditions of soil and weather are favourable to beneficial results.

Table XXII.—Effect on yield of plant canes of early dressings of nitrogen, phosphate and potash on a lightly calcareous soil.

Soil type: Bendall's clay (0.4 per cent. $CaCO_3$).
Estate: Greencastle.
Variety: B. 726. *Manured*: 26/4/35.
Planted: 26/1/35. *Reaped*: 6/4/36.
Rainfall ($14\frac{1}{2}$ months): 54 inches.
Layout: Randomised blocks. *Plot size*: 1/161 acre.

Manurial treatment per acre.	Yield of plants* tons per acre.	Gain t.p.a.
Nil	33.62	—
2 cwts. sulphate of ammonia 2 cwts. superphosphate 2 cwts. muriate of potash	40.21	6.59

* Mean values for four replicates.

Calcareous soils.

Four experiments with nitrogen, phosphate and potash on plant canes have been reaped on calcareous soils, two on Gunthorpe's clay and two on Fitches clay. In one of the experiments on each soil type the phosphate and potash were applied early in the life of the plant canes. In the other experiments these manures were applied late.

Early Treatment with Phosphate and Potash.

Measures of the effect of an early dressing to the acre of 2 cwts. of superphosphate and 2 cwts. of muriate of potash, when applied alone and in the presence of late, and early and late, dressings of sulphate of ammonia, on an area of Gunthorpe's clay containing 7.2 per cent. of calcium carbonate, are set out in Table XXIII. The experiment was laid down in the form of two Latin squares. The five main plots of the rows and columns were occupied by the treatments with nitrogen. Each main plot was divided into two halves and one of the half plots, chosen at random, was dressed with phosphate and potash. The phosphate, potash and early nitrogen were applied six weeks after planting, *i.e.*, before the beginning of the dry season. The late nitrogen was added four and a half months after planting.

Three important deductions can be drawn from these data:—

(1) As in the case of the other experiments on calcareous soils (Table XVI) the response in yield of plant canes to early treatment, and to early and late treatment, with sulphate of ammonia, when applied alone, was small.

(2) Late treatment with sulphate of ammonia in addition to early treatment with superphosphate and potash gave rise to a gain no larger than that resulting from late treatment with sulphate of ammonia alone.

(3) Early and late treatment with sulphate of ammonia, together with early superphosphate and potash, gave rise to an immediate gain in yield of 5.29 tons of cane, an increase which is not only statistically significant but comparable in size with the gain in yield of plant canes which dressings of 12 to 36 tons of pen manure can give rise.

Table XXIII.—Effect of early and late treatments with nitrogen, and early treatment with phosphate and potash, on yield of plant canes on a calcareous soil.

Soil type: Gunthorpe's clay (7.2 per cent. $CaCO_3$).
Estate: Delaps. *Variety*: B.H. 10(12).
Manured: 27/1/35 (early), 11/6/35 (late).
Planted: 17/12/34. *Reaped*: 7/3/36.
Rainfall ($14\frac{3}{4}$ months): 49 inches.
Layout: Two 5 × 5 Latin squares with half plots.

Yields are expressed as tons cane per acre.

Main Plots.		Half Plots.			
Early S/A (27/1/35).	Late S/A (11/6/35)	Nil.		Phosphate and potash (27/1/35).	
Nil	Nil	25.86		28.01	
Nil	2 cwts.	27.21	28.17	26.82	28.23
Nil	4 cwts.	29.12		29.73	
2 cwts.	2 cwts.	27.46	26.35	30.25	31.15
2 cwts.	4 cwts.	25.24		32.05	

Average immediate gain from:
Late nitrogen (alone) = 2.31 tons cane.
Early and late nitrogen (alone) = 0.49 tons cane.
Late nitrogen, early phosphate and potash = 2.37 tons cane.
Early and late nitrogen, early phosphate and potash = 5.29 tons cane.

The interaction of sulphate of ammonia with phosphate and potash on this calcareous soil can be shown to be statistically significant.

The yield data for the second experiment with nitrogen and early phosphate and potash, which was laid down on a shallow Fitches clay containing 34 per cent. calcium carbonate, are summarised in Table XXIV. The manures were applied at the same rate as in the previous trial. The layout was similar except that randomised blocks were used instead of Latin squares. The variety of cane planted was P.O.J. 2878.

The results given by this experiment lend confirmation to those obtained on the calcareous Gunthorpe's clay. Small gains in yield of plant canes resulted from treatment with sulphate of ammonia alone. There is little to choose between the effect of late sulphate of ammonia with early superphosphate and potash and the effect of late sulphate of ammonia alone. Early and late sulphate of ammonia with early superphosphate and potash, however, gave rise to a significant immediate gain in yield of 4.66 tons of cane.

Table XXIV.—Effect of early and late treatment with nitrogen, and early treatment with phosphate and potash, on yield of plant canes on a highly calcareous, shallow soil.

Soil type: Fitches clay, shallow phase (34 per cent. $CaCO_3$).
Estate: Vernons. *Variety*: P.O.J. 2878
Manured: 23/1/35 (early), 6/6/35 (late).
Planted: 13/12/34. *Reaped*: 2/3/36.
Rainfall (15 months): 46 inches.
Layout: Eight randomised blocks with half plots.

Yields are expressed as tons cane per acre.

Main Plots.		Half Plots.			
Early S/A (23/1/35).	Late S/A (6/6/35).	Nil.		Phosphate and potash (23/1/35).	
Nil	Nil	9.20		9.50	
Nil	2 cwts.	9.64	9.80	10.77	11.16
Nil.	4 cwts.	9.96		11.55	
2 cwts.	2 cwts.	11.66	12.07	13.05	13.86
2 cwts.	4 cwts.	12.47		14.67	

Average immediate gain from:

Late nitrogen (alone)	=	0.60 tons cane.
Early and late nitrogen (alone)	=	2.87 tons cane.
Late nitrogen, early phosphate and potash	=	1.96 tons cane.
Early and late nitrogen, early phosphate and potash	=	4.66 tons cane.

The yields obtained in this experiment on Fitches clay were small, partly because the soil is shallow and partly because the rainfall during the first eight months of the life of the plant canes was very low. The conditions therefore were such as to impose a severe test on the value of inorganic manures. It is of interest that the remainder of the field, which was dressed with sheep manure before planting, gave a yield to the acre of 10.5 tons of plant canes. The position of the experimental area in the field was not specially chosen.

It should be noted that equally large immediate gains in yield of cane might have been obtained from a smaller total dressing of inorganic manures in these experiments with nitrogen, phosphate and potash on the Gunthorpe's and Fitches clays, and that it remains a matter of experiment to determine the optimum economic dressings.

Late Treatment with Phosphate and Potash.

The yield data for the remaining experiments on calcareous soils are recorded in Table XXV. They differ from the two former trials in that the phosphate and potash were not applied until after the end of the dry season following planting.

Table XXV.—Effect of early and late treatments with nitrogen, and late treatment with phosphate and potash on yield of plant canes on calcareous soils.

Soil type:	Gunthorpe's clay (26 per cent. $CaCO_3$).	Fitches clay (16 per cent. $CaCO_3$).
Estate:	Carlisle.	Parrys.
Variety:	B.H. 10(12).	B.H.10(12).
Planted:	23/10/34.	25/10/34.
Manured:	8/12/34 (early) 25/6/35 (late).	7/12/34 (early). 9/7/35 (late).
Reaped:	25/2/36.	28/2/36.
Rainfall:	62 inches (16 months).	62 inches (16 months).

Layout: Two 5 × 5 Latin squares at each site.

Manurial treatments per acre.		Yield of plant canes (t.p.a.)	
Early (Dec. 1934)	Late (June-July, 1935).	Gunthorpe's clay.	Fitches clay.
Nil	Nil	16.45	30.63
Nil	2 cwts. S/A	16.91	31.64
Nil	2 cwts. S/A, 2 cwts. potash, 2 cwts. phosphate.	15.98	31.96
2 cwts.	2 cwts. S/A	16.49	31.04
2 cwts. S/A	2 cwts. S/A, 2 cwts. potash, 2 cwts. phosphate.	16.75	32.10

Only small gains in yield of plant canes resulted from the late treatment and from the early and late treatment with sulphate of ammonia. The gain from late treatment with sulphate of ammonia in the presence of phosphate and potash also was small. Further, no appreciable additional gain resulted from the inclusion of an early treatment with sulphate of ammonia in the presence of late phosphate and potash.

On the basis of these experiments it would appear that satisfactory gains in yield of plant canes on the calcareous soils may not result from early treatment with nitrogen in the presence of phosphate and potash unless the phosphate and potash are applied early in the life of the plant.

Summary.

In two experiments on lightly calcareous soils immediate gains in yield of 11.35 tons and 6.59 tons of plant canes have been obtained from dressings of complete inorganic manure. In one of these experiments nitrogen, phosphate and potash are known each to have contributed independently towards the gain. In a third experiment on a lightly calcareous soil a late dressing of complete inorganic manure failed to give rise to an immediate gain in yield of plant canes.

In two experiments on calcareous soils a complete inorganic manure gave rise to immediate gains in yield of 5.29 and 4.66 tons of plant canes. These gains, which are comparable with the immediate gain to which dressings of 12 to 36 tons of pen manure can give rise, were obtained on the plots which received dressings of nitrogen, phosphate and potash shortly after planting and before the beginning of the dry season. Sulphate of ammonia alone, and phosphate and potash without sulphate of ammonia, failed to give satisfactory results.

In two other experiments on calcareous soils, in which the phosphate and potash were not applied until after the end of the dry season following planting, a complete inorganic manure failed to give rise to satisfactory gain in yield.

Summary.

There are recorded in this paper the results of a series of manurial experiments reaped in Antigua in 1936. The experiments were laid down under the auspices of the Sugar-Cane Investigation Committee of the island.

Organic Manures.

Pen Manure.

Method of application.

Under one set of conditions it has been found that there is nothing to choose between the relative merits of burying pen manure under the banks before planting and applying it in the furrows after planting, in relation to yield of plant canes.

Response in yield of plant canes.

In only three out of seven experiments has treatment of plant canes with pen manure been found to result in satisfactory immediate gain in yield.

The success or failure of pen manure in this respect does not appear to depend primarily on the concentration of calcium carbonate in the soil, on the quality of the manure, or on time of application of the dressing to the plant canes. It does appear to depend on the manurial history of the soil, for the three experimental areas on which satisfactory gains were recorded are known to have been regularly manured at previous replantings.

It has been found elsewhere (3, 4) that nitrogen and potash in pen manure may be available to the crop of plant canes to which the dressing is applied, but that the phosphate may not become largely available until the ratoon stages of the crop. Under conditions which obtain in Antigua it appears essential for plant canes to have an adequate supply of phosphate early in their life. On areas which have not been regularly manured in the past it is probable that the store of available nutrients in the soil is low, and pen manure is unlikely to release the necessary phosphate in available form until it is too late. On areas which have been regularly manured a store of available nitrogen, phosphate and potash has probably accumulated in the soil. In such circumstances there is good reason to believe that later dressings of a suitable manure, whether organic or inorganic in character, are capable of beneficial effect on yield.

Size of dressing.

It would appear from the successful experiments that the optimum dressing of pen manure for maximum financial gain lies in the region of 12 tons to the acre.

Cost.

The cost of pen manure, applied in the field, approximates to $1.50 a ton in Antigua.

Filter-Press Mud.

Response in yield of plant canes.

Late dressings of filter-press mud have so far been found to give rise to satisfactory immediate gain in yield in one of three experiments. This experiment was laid down on an area known to have been regularly manured in the past.

Size of dressing.

About three tons of filter-press mud to the acre appears to be the optimum dressing.

Inorganic Manures.

Sulphate of Ammonia.

Method of application.

In one experiment on plant canes, laid down on a lightly calcareous area, burying sulphate of ammonia in manure holes gave rise to no greater gain than scattering the dressing on the surface of the soil.

Response in yield on lightly calcareous soils.

Satisfactory immediate and residual gains in yield of plant canes and ratoons have been obtained from appropriate use of sulphate of ammonia on continuously cropped areas of lightly calcareous soils of the island.

Response in yield on calcareous soils.

Small gains or small losses in yield have been found to result from the use of sulphate of ammonia, alone, on calcareous soils. Lack of satisfactory response to the manure does not appear to depend on the manurial history of the soil, or on rainfall. It does appear to depend on the presence in the soil of calcium carbonate in excess.

Sulphate of Ammonia v. Nitrate of Soda.

Response in yield.

On lightly calcareous soils there appears little to choose between the immediate and residual beneficial effects of sulphate of ammonia and nitrate of soda. On calcareous soils nitrate of soda as well as sulphate of ammonia fails to give rise to satisfactory gain in yield.

The failure of sulphate of ammonia on calcareous soils cannot therefore be ascribed to tardy nitrification of the ammonium ion.

Sulphate of Ammonia with Inorganic Phosphate and Potash.

Response in yield on lightly calcareous soils.

In two experiments on lightly calcareous soils immediate gains in yield of 11.35 and 6.59 tons of plant canes have been obtained from dressings of complete inorganic manure. In one of these experiments nitrogen, phosphate and potash are known each to have contributed independently towards the gain.

In a third experiment a late dressing of complete inorganic manure failed to give rise to immediate gain in yield of plant canes.

Response in yield on calcareous soils.

In two experiments on calcareous soils a complete inorganic manure gave rise to immediate gains in yield of 5.29 and 4.66 tons of plant canes. These gains, which are comparable with the immediate gain to which dressings of 12 to 36 tons of pen manure can give rise, were obtained on the plots treated with nitrogen, phosphate and potash shortly after planting and before the beginning of the dry season. Sulphate of ammonia, and phosphate with potash, when applied early but independently, failed to give satisfactory results in these experiments.

In two other experiments on calcareous soils a complete inorganic manure failed to give rise to satisfactory gains in yield, but the phosphate and potash were not applied until after the end of the dry season following planting.

References.

(1) Turner, P. E. (1934).—A critical review of agricultural practices on sugar estates in Antigua, with special reference to a scheme of field experiments. *Sugar-Cane Investigation Committee of Antigua.*

(2) Turner, P. E., Charter, C. F. and Warneford, F. H. S. (1936).—Investigations on sugar cane and sugar-cane soils in Antigua, I. *Tropical Agriculture*, XIII, 1, p. 19; 2, p. 38.

(3) Turner, P. E. (1935).—Recent investigations on sugar cane and sugar-cane soils in Trinidad, II. *Tropical Agriculture*, XII, 11, p. 293; 12, p. 320.

(4) Turner, P. E. (1936).—Field experiments on sugar cane in Trinidad. *Annual Report for* 1936, p. 60.

(5) Turner, P. E. and Potter, J. A. (1932).—Manurial experiments with sugar cane, IV. *Tropical Agriculture*, IX, 2, p. 44.

(6) Quintus, R. A. (1923).—*The cultivation of sugar cane in Java.* Norman Rodger, London.

(7) Earle, F. S. (1928).—*Sugar cane and its culture.* J. Wiley and Sons, New York.

(8) Turner, P. E. (1932).—Manurial experiments with sugar cane, I. *Tropical Agriculture*, IX, 5, p. 153.

(9) Turner, P. E. (1935).—Field experiments on sugar cane in Trinidad. *Annual Report for* 1935, p. 4.

REVIEWS.

THE LAND—NOW AND TOMORROW.

By R. G. Stapledon, C.B.E., M.A., *Faber and Faber Ltd.*, London. Pp. 366. price 15s.

The theme of this book is most clearly and succinctly expressed by the opening quotation, "This blessed plot, this earth, this realm, this England". It is written by a countryman who has been gifted with an innate love of the country in the widest sense of the word and who combines in himself the rather unique qualities of the idealist, the enthusiast and the man of practical experience. It is hardly to be wondered that, with such a subject to write about, the book is both an inspiration and a warning, an inspiration in outlining the future possibilities of the land under controlled development, and a warning of what will inevitably happen if the present haphazard methods of "laissez-faire" in agricultural policy are allowed to continue. For example, it is estimated that, unless a much more progressive land policy is adopted in the near future, rural England, as we know it today, will soon have disappeared never to return. Statistics show that at present only some 20 per cent. of the whole population of England and Wales dwell in rural areas and less than seven per cent. of the country's workers are employed in agricultural pursuits. The steady drift of the rural population towards the towns is depopulating the country at an alarming rate. This drift is the direct result of various fairly obvious sociological factors such as the low values offered for farm labour and farm produce, the transition from arable to grass, the economy in labour coming from mechanised farming, the lack of recreation facilities and general amenities in the country, and so on. At the same time, the towns are extending their boundaries over an ever widening area, and this, in conjunction with ribbon development will, at the present rate of progress, completely de-ruralise England in some 400 to 700 years, a relatively short period in racial history. The final product will apparently be a sort of suburbanised hybrid between town and country, which will include many of the worst features of both communities.

If this prophecy is to be avoided, a drastic change in the existing land policy is required. Misuse of the land, especially where the land surface is decidedly limited as it is in Great Britain, is an outrage to posterity. It is necessary to plan not for five or ten years ahead, but for at least a century, and to plan with foresight and imagination on a national basis in which both the urban and rural viewpoints are given due weight. Any working-plan devised must have, as its primary objective, land preservation and improvement. In the long run, this can be best achieved by grading up the soil fertility by suitable modification of the current farming practice so as to make full use of recent scientific discoveries and adapt them to modern conditions. The need for improvement in the quality of the produce and in the general status of the rural population is not forgotten. In fact, the countryman himself is regarded as the most valuable product of the land. A healthy

and thriving rural population has long been recognised as essential to a progressive nation in order to ensure both the physical standards of the race and also a sane and balanced philosophy. This idealisation of the land and its people is probably justifiable and is certainly not at all uncommon among writers who have been closely associated with country life in all its aspects. For example, Mr. A. G. Street in a recent novel* has, as his main theme, the sanctity of the land and the sterling worth of the true countryman.

Mr. Stapledon is not merely a theorist. Having effectively introduced his various arguments demonstrating the need of concerted action towards land development, he then considers farming as it is practised today and indicates the lines along which improvement can most easily be effected. His statements, both in regard to the present position and also with reference to his proposals for improvement, are supported by a wealth of data and by a wide practical experience of farming in many different counties and under very varied conditions. He deplores the present tendency towards permanent grass as a retrograde step. His ultimate ideal is an England with a high proportion of the total land surface under improved grazings in one form or another, but in nearly all cases, these are to be in the nature of long or short duration leys and not of permanent pasture. The plough in its most modern form is still to be the foundation stone of good farm practice. He shows how on all types of land from the poorest hill grazings to the richest arable lands, there should be a gradual grading up of the quality of the vegetation they carry, and describes how this can best be effected over periods of from 3 to 20 years depending on existing conditions. The financial side is not neglected and figures are given to prove that, in the long run, the capital outlay required for reconditioning the land will be more than recovered by the increase in the quality and quantity of the produce. The chief obstacle to progress on the lines suggested appears to be a very serious lack, among the farming community, of the necessary foundation capital to start operations, a state of affairs which can only be surmounted by carefully administered Government subsidies or loans.

A second and very real obstacle to land improvement is the lack of security of tenure of the majority of the farmers. Without this, there can be little encouragement to build up soil values as distinct from mere fertility maintenance, and the only remedy would appear to be the establishment of many more owner occupiers of whom there is only some 30 per cent. today. Under the proposed new conditions, the optimum economic unit, especially where capital is scarce, is reckoned to be under 100 acres in size.

The urban community has also to be catered for by a real back-to-the-land movement, entailing the establishment of National Parks, Trade Holiday Estates and week-end allotments on a national scale.

In the closing chapters, the means by which these various reforms are to be enforced are considered. This includes as an essential preliminary, a detailed survey of the whole land surface in which close co-operation between the different types of scientist—botanists, chemists, geologists, engineers, &c.—will be required, and full use made of the modern method of aerial survey. A Ministry of Lands would have to be formed with wide powers and terms of reference, so as to co-ordinate all the different demands on the land by the various sections of the community —farmers, county councils, port authorities, railway and road boards, &c. The crying need of bridging the gap between scientific research and farming practice is also emphasized.

As the author is planning for the somewhat distant future, many of the ideas are, of necessity, all too briefly sketched in, and others are apparently impracticable or based on a rather idealised standard of human endeavour. Many of the theories are distinctly revolutionary and controversial, such as the reduction of working days rather than of hours per day, the alteration of the calendar to eliminate the week-end feature of modern life, the radical reform of the education system, the advocacy of a rather narrow nationalism as regards agricultural policy and so on. The main plea that a start should be made, and must be made, is not affected by these issues. The pleader is one who has studied his subject deeply and backed his suggestions by a multitude of irrefutable facts. Provided the effort is made on a national scale, solution of the problem will surely follow, if by no better system than that of trial and error.

Nor in the reviewer's opinion, is this particular problem entirely estranged from conditions prevailing in the Dominions and the Colonial Empire. Experience in the tropics still shows land exploitation of the most primitive type coupled with erosion in the grand manner. A definite and successful land policy in England would serve to emphasise the equally great need for a similar reform in the Colonies. Local administrations would then be compelled to pass and enforce such legislation as would be required to preserve intact the land surface and gradually build it up to its highest potential level of fertility.

D. D. P.

* "The Last Gentleman."

* * *

FLORA OF JAMAICA VOL. VII

By. W. Fawcett and A. B. Rendle, *Trustees of The British Museum*, London, 1936. pp. 304, price 15/-.

A welcome appearance is that of Vol. VII of Fawcett and Rendle's Flora of Jamaica. Since the death of Mr. Fawcett the work has been continued by Dr. Rendle and in the present volume (*Rubiaceae, Caprifoliaceae, Campanulaceae, Goodeniaceae, Compositae*) he has had the assistance of the late Mr. Spencer Moore. The volume is uniform with those that have preceded it, and like them contains useful illustrations.

E.E.C.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Report on Clarification of the South African Sugar Technologists' Association, 1935-36. *By G. C. Dymond.*

A laboratory study of the chemical characteristics of the non-Uba and the Uba canes has been made, all tests being carried out on the mixed juice under comparative conditions obtained from consignments representative of a wide area. They are summarized in the following tables :—

Brix and Purity.

Variety.	Age in months.	Average Brix.	Purity. Minimum.	Purity. Maximum.
Co. 290	Under 16	14.96	78.8	91.8
Do.	Over 16	17.48	80.5	93.4
POJ 2725	Under 16	16.08	82.9	89.1
Do.	Over 16	17.37	83.3	94.2
POJ 2878	Over 16	15.40	85.7	94.1
Uba	Over 16	15.37	82.4	92.9

Reducing Sugars Ratio.

Variety.	Age in months.	Reducing Sugar Ratio. Minimum.	Reducing Sugar Ratio. Maximum.
Co. 290	Under 16	0.06	4.66
Do.	Over 16	0.45	5.86
POJ 2725	Under 16	1.22	4.26
Do.	Over 16	0.39	3.75
POJ 2878	Over 16	0.72	3.07
Uba	Over 16	0.91	4.72

Ash per cent. Brix.

Variety.	Age in months.	Ash per cent. Brix. Minimum.	Ash per cent. Brix. Maximum.
Co. 290	Under 16	1.14	4.22
Do.	Over 16	1.18	3.99
POJ 2725	Under 16	1.86	4.31
Do.	Over 16	1.70	3.95
POJ 2878	Over 16	1.11	2.07
Uba	Over 16	1.28	4.25

Analyses of the ash of composite samples of the mixed and clarified juices from the above canes were also made. These determinations showed the non-Uba canes to give a higher total ash in both mixed and clarified juices. It was the soluble ash, chiefly potash, that was appreciably higher; silica was of course higher in the Uba juices, as was also the iron and alumina, and lime, but the magnesia was lower. P_2O_5 was about the same in the two series.

Another series of tests made was intended to show the comparative amounts of lime required to bring the juices to 8.4 pH, the results being expressed in lbs. of CaO per 1,000 gallons with some of the minimum and maximum figures as follows: Uba, 4.00, 7.96; Co 290, 3.05, 7.16; POJ 2725, 3.35, 6.90; and POJ 2878, 3.74, 7.54. If the present practice in South Africa of liming to 8.4 pH were continued, one would expect a possible maximum saving of about ½ lb. of lime per 1,000 gallons.

Comparative laboratory experiments were also carried out on clarification by simple defecation and with phosphoric acid treatment, these leaving the Committee to observe that in general the Uba juices gave higher volumes of mud, but that in the non-Uba series the clarity figures were superior, especially with phosphoric acid treatment. In the light of these laboratory tests, and from information from practical factory experiments, the Committee is not justified in assuming that a departure from present technique is warranted. It is not a certain prospect, they add, that the treatment of non-Uba juices will require appreciably less chemicals for clarification.—(*Int. Sugar Jr.*, Vol. XXXIX, No. 460, pp. 156-7, 1937.)

* * *

Use of Hand Refractometer in Estimating Maturity of Sugar Cane—*By S. Duncan.*

It is apparent that the hand refractometer is a suitable instrument for the rapid execution of a scheme of maturity testing. As regards the sampling technique for individual stools or stalks, there appear to be two general methods. Workers in India, Queensland, Jamaica and Barbados favour the division of whole stalks into top and bottom, or top, middle and bottom sections for examination.

Investigations in Java and later work in Queensland appear to be directed towards the collection of composite samples of juice by piercing a large number of stalks at a certain internode containing juice typical of the whole cane. As regards the method of collecting a sample representative of the whole field, recommendations vary, and in view of the marked differences in stand and habit of cane in the various countries it would appear advisable to investigate this problem for each particular area.—(*Int. Sugar Jr.*, Vol. XXXIX, No. 439, p. 111, 1937.)

EFFICIENT RAT TRAP.

An effective rat trap can be made from a kerosene tin. Cut the top away, and have about six inches of water in the bottom. Float chaff on the surface of the water so that the rats do not see it, and on the chaff rest the bait, something rather strong, such as a piece of old meat. Lean a plank against the side of the tin so that the rats can climb up to the top of the tin. One drowned rat does not preven others from jumping in. It is possible to catch quite a number of rats in this way.—(*Queensland Agricultural Journal.*)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Citrus Wine.

In a recent article in *Industrial and Engineering Chemistry*, Vol. XXVIII, pp. 1224-1229, 1936, Messrs. H. W. van Loesecke, H. H. Mottern and G. N. Pully of the U.S.D.A. Citrus Products Station, Florida, describe the preparation of wines, brandies and cordials from Citrus fruits, such as grapefruit and orange. Cane sugar or corn sugar is added to the expressed juice, and the liquid is then inoculated with pure cultures of wine yeast. The resulting fermentation is carefully controlled. The Citrus wines produced differ in odour and taste, but the flavours do not resemble those of the unfermented fresh juices.

The fruits used for making wines are third grade and culls. The juice is extracted by burring or reaming, and then strained. The bitter taste of grapefruit juice unfortunately is transmitted to the wine, but it may be removed from the fermented liquid by filtration with activated charcoal. The pure wine yeast cultures are obtainable from the American Type Culture Collection at Chicago. The alcohol content of Citrus wines ranges from about 10 to 17 per cent., requiring the addition of 1½ to 1¾ lb. of sucrose to each gallon of the initial juice before fermentation. The temperature must be kept at about 60°F (16°C) to prevent the development of undesirable acetic organisms. The period of fermentation is 10 or 11 days.

Fortified wines may be made by adding Citrus spirits. Spirits and brandies are prepared by distilling the strained wines, the distilled spirit being "aged" in charred casks. Grapefruit and orange brandies do not possess the flavour of the fruits, although their flavours are different from one another. Citrus cordials are made by adding sugar syrup to citrus spirits, together with a little rind essential oil. They contain 33 per cent. of alcohol and 37 per cent. of total sugars.

* * *

Adhesives from Soya Protein.

While it has long been known that the chief protein of the soybean, glycinin, which is present in the bean to an extent of 35 per cent., is readily soluble in dilute alkalies and is coagulated by dilute acids, it was not until 1918 and 1919 that these properties found application in industry through the patents of S. Satow. These patents have since expired, and Satow's method of extraction of soybean oil from the beans by benzine, as well as the extraction of the soybean protein from the meal by alkalies, is now open to the public. By Satow's method the beans are first dried, and where a light-coloured material is desired, the hulls are removed previous to the flaking of the beans. This is followed by benzine extraction. The solvent-extracted meal is treated by dry heated air (not over 40°C.) with agitation or by vacuum, in order to remove the remaining benzine. Steam treatment should be avoided, since it denatures the protein.

The meal obtained is then treated with aqueous solutions of sodium, potassium, or ammonium hydroxide (or carbonate), and the protein extract separated by filtration, centrifuging, or by other means. From the liquid obtained, the protein (glycinin) is precipitated by dilute acids, such as sulfuric, sulfurous, phosphoric, acetic, or lactic acid. The precipitate is allowed to settle, the supernatant liquid is drawn off, and the settled precipitate is then pressed into cakes, and, if desired, dried and pulverized. The soya protein thus obtained is recommended by Satow as material for the manufacture of adhesives. An adhesive of satisfactory quality can be made by using the formula :—

Water 500, Soya protein 100, Calcium oxide 15, Sodium silicate 7, Cement 2.

Its average shearing strength is 31.3 (on veneer, by Amsler's testing machine), and its water resistance 5.2 by Amsler's testing machine after boiling the veneer in water for one hour. The incorporation of sodium hydroxide into the formula results in a reduced water resistance. It has been established that the adhesive strength of a soya glue depends upon the quality of the soya protein used. The method of extraction of the protein from the soybean oil meal is of great importance, as well as whether the meal is a pressed meal or a solvent-extracted meal. In 1933, Iinume and Mashino published the results of their studies on the shearing strength of soybean protein as an adhesive, and came to the conclusion that the maximum strength was obtained where the beans were extracted by a mixture of benzine and methyl alcohol. Protein derived from press meal (1,800 lb. and 3,800 lb. pressure per sq. in.) was much inferior as a material for adhesives.—(*Ind. & Eng. Chem. News Ed.*, Vol. 14, No. 24, p. 500, 1936.)

* * *

Differential Browsing by Deer on Plots variously Fertilized.

White-tailed deer (*Odocoileus virginianus*) browsed heavily on flowering dogwood (*Cornus florida*) that had been fertilized with a mixture of sodium nitrate and ammonium sulphate, but did not browse extensively on plants that had been fertilized only with phosphate or potassium compounds. Leaves that were browsed to the extent of only 3.6 per cent., and those that were browsed to the extent of 66.0 to 83.7 per cent., contained nitrogen 1.288, 2.362 to 2.983, and reducing sugars 6.03, 7.40 to 7.96 per cent. on the dry weight respectively. Within certain limits, the concentration of reducing sugars in the leaves increased with increase in the amount of nitrogen fertilizer applied. The frequency and intensity of browsing appeared to follow the sugar content of the leaves more closely than the nitrogen content.—(H. L. Mitchell and N. W. Hosley in *Black Rock Forest Papers*, 1, 24-7 (1936.) Abstr in *Chemical Abstr.*, Vol. XXX, No. 17, 1936, p. 6115.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association.

	American Mid.	*Egyptian F.G.F. Sakel.*
25th March	7.95	12.68
2nd April	7.97	12.76
9th April	7.87	12.33
16th April	7.47	12.05
23rd April	7.49	11.90
30th April	7.22	—
7th May	7.45	—
14th May	7.12	—
(15*th May*, 1936)	6.56	9.03

After recording substantial advances, prices for American raw cotton have fallen mainly owing to the rumours concerning monetary policy in the U.S.A. and also because of the budget proposals regarding the new form of taxation. Demand, however, continues to be encouraging. A good business has been done in West Indian Sea Islands at prices ranging from 22*d.* to 24*d.*

* * *

BANANAS.—According to the *West India Committee Circular* for 22nd April prices of Jamaicas are £1 10*s.* 0*d.* per ton higher at £18 15*s.* delivered London and £18 10*s.* nearest station Provinces. Brazilians are in poor demand and quoted at £1 lower at £14 delivered London and £15 Province.

* * *

LIME PRODUCTS.—*Lime Oil.*—The small supplies of Handpressed are firmly held for 40*s.* per lb. Fair sales of Distilled have been made at 25*s.* per lb., and stocks are lower. *Lime Juice.*—There is more enquiry for Concentrated but the demand is still limited. The demand for Raw is slow with the value nominal at 2*s.* 3*d.* to 2*s.* 6*d.* per gallon.—(*West India Committee Circular* 22nd April.)

* * *

COCOA.—Since last writing the cocoa market has shown great weakness with practically no demand from manufacturers. With the approach of the summer months, usually a dull time in the cocoa industry, there is little in the picture to cause any immediate upward trend. An irregular market may therefore be expected for the present, with a likelihood of still lower levels being established. Further declines, however, should prove to be more orderly due to the better class of buying bound to appear if prices go lower. New crop Accra is offered at 38*s.* and locally $12.00 a fanega for Plantation cocoa is generally paid.—(*By Courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.) :—

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
1st April	6	9¾	10	6¾
8th April	6	7½	10	3¾
15th April	6	6	10	3
22nd April	6	3¾	10	0¾
29th April	6	3¾	10	0¾
4th May	6	1½	9	10½
11th May	6	4½	10	1½
(14*th May*, 1936)	4	9	8	6

Although on the whole an active tone has prevailed in the market, raw sugars have followed a declining tendency due to profit taking and stop loss orders. The article, like other commodities has not yet fully recovered from the shock occasioned recently by rumours of a contemplated change in the gold policy of the United States and has also been under the spell of the continued weakness of the Stock Exchange. There has been good news of the International Sugar Conference whose negotiations have been progressing most satisfactorily. The market was ripe for a reaction after the sharp advances of the last few weeks and the recent unloading has added health to its technical position.

* * *

RUBBER.—Quotations for plantation sheet have ranged as follows :—

	Pence per lb.
31st March	13 3-8
7th April	12 1-8
14th April	11 1-8
21st April	11 1-8
28th April	10 3-16
5th May	10 3-8
13th May	10 5-16
(13*th May*, 1936)	7 5-16

The market since our last report has developed a distinctly easier tone which has been accompanied by wide fluctuations in prices. The decline was started by rumours emanating from New York that the United States Treasury intended to drop their buying price for gold in order to prevent any further inflationary tendency in securities and commodities. These rumours, however, were specifically denied by President Roosevelt and later again by Treasury Officials at Washington. The chief cause of the decline was heavy liquidation of speculative commitments. Meanwhile home trade deliveries remain good and United Kingdom stocks continued their gradual decline. According to the *American Questionnaire* the U.S.A. consumption for March was 52,983 tons and for January-March, 1937 151,963 tons as against 127,954 tons for the same period last year.

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE.

COLLEGE NEWS BULLETIN

JUNE, 1937.] [No. 1.

COLLEGE NEWS.

IN MEMORIAM

SIR JAMES CURRIE, K.C.M.G., K.B.E.

For ten years Chairman of the Governing Body of the Imperial College of Tropical Agriculture.

Died Wednesday, 17th March, 1937.

The Principal accompanied by Lady Evans, expects to sail for England by s.s. *Simon Bolivar* on 21st June.

* * *

Mr. R. C. Wood, Professor of Agriculture and Miss Wood sailed for England by m.s. *Colombia* on 10th May.

* * *

Mr. G. R. Langdale, Bursar, accompanied by his wife and son sailed for England by s.s. *Simon Bolivar* on 14th April.

* * *

Mr. C. Y. Shephard, Professor of Economics, accompanied by his wife and son sailed for England by s.s. *Colombie* on 23rd May.

* * *

Mr. C. C. Skeete, Assistant Commissioner of Agriculture and Mrs. Skeete, sailed for England from Barbados by m.s. *Colombia* on 11th May.

* * *

Sir Donald Charles Cameron, G.C.M.G., K.B.E., late Governor of Nigeria, has been co-opted a member of the Governing Body of the College.

* * *

Mr. F. Hardy, Professor of Chemistry and Soil Science, accompanied by Mrs. Hardy and Miss Betty Hardy expects to sail for the U.S.A. on 28th May.

* * *

We offer our congratulations to Sir Eliot de Pass who is a Governor of the College on being appointed a Knight Commander of the Most Excellent Order of the British Empire.

We offer our heartiest congratulations to Mr. O. J. Voelcker who has been seconded to the College by the Government of Nigeria for cacao research, on his engagement to Miss Genevieve McCormick Bird, youngest daughter of the late Mr. Arthur H. S. Bird and of Mrs. Bird, of Salt Lake City, Utah.

* * *

We offer our congratulations to Mr. F. A. Stockdale, C.M.G., C.B.E., Agricultural Adviser to the Secretary of State for the Colonies, on being appointed a Knight Commander of the Most Distinguished Order of St. Michael and St. George. Sir Frank Stockdale who has been for several years on the Governing Body of the College as a co-opted member has recently been nominated by Mr. Ormsby-Gore to represent him on the Governing Body.

* * *

The following recently visited the College: The Earl of Harrowby; Mr. R. W. R. Miller, Director of Agriculture, Barbados; Mr. J. F. Bethune-Baker; Colonel R. ff. Willis and Mrs. Willis; Sir Frederick and Lady Keeble; Mr. F. Burnett, Acting Director of Agriculture, British Guiana; Mr. T. A. Twyman; Sir John Cadman; Mr. R. S. Mackilligin; Mr. Atherton Lee; Col. A. R. Dick; Brigadier-General R. Howlett; Mr. F. M. Oliphant and Major C. L. Appleton.

* * *

Dr. H. Rex Barnell, M.A., Ph.D. (Camb.) B.Sc. (Lond.) who has been appointed Biochemist to the Low Temperature Research Station, arrived in Trinidad, accompanied by his wife, by s.s. *Venezuela* on 21st February. Dr. Barnell was educated at Luton Modern School and Downing College, Cambridge. While he was at Cambridge he took the Natural Sciences Tripos with honours and in 1929 was awarded the Frank Smart Prize for Botany. From 1929 to 1931 he received the Department of Scientific and Industrial Research Grant and worked under Dr. F. F. Blackman, and in 1931 was elected to the University Frank Smart Studentship in Botany. In 1932 he accepted the post of Lecturer and Research Assistant in Plant Physiology at the Cambridge School of Agriculture where he carried out biochemical research on the carbohydrate metabolism of the wheat plant.

MR. N. WRIGHT, B.Sc.

Mr. Nigel Wright who has resigned from the post of Senior Lecturer in Botany at the College to become Advisory Botanist at the Rubber Research Institute, Malaya, left Trinidad on 5th May. Mr. Wright was educated at Gresham's School, Holt, and at London University where he obtained the B.Sc. with honours. In 1930 he was awarded a Colonial Agricultural Scholarship and in 1931 came out to Trinidad as a Colonial Office Cadet. He took and obtained the Associateship of the College and in September 1932 was appointed Lecturer in Botany. He was promoted to a Senior Lectureship in 1935.

During his period of office Mr. Wright, in addition to his duties as lecturer, devoted much time to citrus research work and studied, in particular, problems connected with rootstocks, vegetative propagation and polyembryony. He was also for two years Honorary Secretary of the Trinidad Science Club. He was a very popular figure amongst us, and the numerous friends whom he made in Trinidad will be sorry to lose him. Our very best wishes go with him in his new field of work.

* * *

ASSOCIATESHIP AWARDS.

The following students have been awarded the Associateship of the College :—

T. Bell, B.S.A. (Hons.), Toronto.
D. R. N. Brown, B.A. (Hons.), Camb.
S. Duncan, Dip. Agr. Sugar Tech., I.C.T.A.
B. de L. Inniss, B.Sc.Agric. (Hons.), McGill.
C. E. Johnson, B.Sc. (Hons.), Leeds, Dip. Agric. (Camb.).
C. O. Lai-Fook, Dip. Agr. Sugar Tech., I.C.T.A.
A. R. Melville, B.Sc. (Hons.), Edinburgh.
M. Moinuddin, Dip. Agr. Sugar Tech. I.C.T.A.,
J. W. Purseglove, B.Sc. (Hons.), Manchester.
C. H. F. Walker, B.A., Oxon.
J. M. Waterston, B.Sc. (Hons.), Edinburgh.
J. M. Watson, B.A. (Camb.), Dip. Agric. (Camb.).
R. D. E. Yearwood, Dip.Agr. Sugar Tech., I.C.T.A.

BIRTH.

Langdale.—On 26th January, 1937, at Port-of-Spain, Trinidad to Joan (*nee* Bartholomew) wife of G. R. Langdale, Bursar, a son.

EXCURSION.

The Post-Graduate Easter Tour, 1937.

In accordance with the usual custom the Colonial Office Scholars made a short tour during the Easter vacation to a neighbouring Colony. The main object of these tours is to give these students an opportunity of seeing something of the working and administration of an agricultural department in a tropical Colony. This year a visit was made to British Guiana, and it was unfortunate that owing to the exigencies of the steamship services, the visit was somewhat shorter than desirable. The result was that a great deal had to be worked into a comparatively short time, and the whole tour only lasted a week.

Arriving on Wednesday, 7th April, at daybreak, the party was met by the Acting Director (Capt. F. Burnett) and members of the Staff of the Agricultural Department, and conducted to the Head Office and laboratories, where Capt. Burnett gave an interesting account of the organization and varied activities of his Department. The rest of the morning was spent in visiting the Stock Farm where bulls of European dairy herds are kept for service, and pigs and poultry are also reared with the object of improving local stock. The Botanic Gardens, the Rice Breeding Station and the Apiary were also visited. In the afternoon, several hours were spent at the Sugar Experiment Station. The system of sugar-cane cultivation, which is so different from that of other countries, was explained in detail by Mr. Holman Williams, who was good enough also to exhibit some of his new seedling canes which have been specially bred to suit Demerara conditions. Of particular interest were the sorghum-saccharum crosses, some of which show signs of good sugar content combined with extremely early maturity. An evening party given by Mrs. Burnett concluded the day.

On the 8th an early start was made at 5 a.m., and the party proceeded by steamer up the Demerara river as far as Dalgin. Here an inspection was made of the pine-apple cultivation belonging to a local company, one of the Directors of which was good enough to make the trip and explain details. The pineapple canning factory is a model one, but unfortunately the Company got into difficulties and the cultivation was kept in abeyance for many months until financial readjustments could be effected.

The soil in this part is a pure white quartzite sand of singularly low fertility, and is said to be typical of large portions of the hinterland of the Colony. Under the heavy rainfall conditions that obtain, it is capable of supporting forest growth, but it would seem doubtful whether it could support permanent field crop cultivations. The system of clearing the land, and of planting and fertilizing pineapples, which would appear to be the most suitable crop for this class of land, was explained in detail by the Manager, Mr. Sleeper, who has had much experience of pineapple cultivation in Hawaii.

On the following day another early start was made at 6 a.m. for Berbice, and a good opportunity was afforded *en route* of seeing the sea defences and the drainage problems of this country. Mr. G. Eccles, the Manager of Plantation Blairmont, and his stafff took the greatest trouble to explain the various methods of cane cultivation that are in use. The system of water fallowing as a means of renovating the land was demonstrated in detail, and much interest was shown in the system of conveying cane to the factory by water. After lunch at Mr. Eccles' house, the return journey was made and some time was spent in going over a typical Indian rice factory and in visiting Miss Mustard's coconut plantation at Letter T. Here the coconuts had suffered for several years in succession from attacks of the leaf eating caterpillar (Brassiolis) and the effects on the size of the nuts and on the health of the trees were very obvious.

On Saturday, visits were made to the Rice Grading Office, the Demerara Cake and Oil Mills, and the Meat Works. At the latter place some of the cattle that are being brought down from the interior savannahs were inspected, and it appeared obvious that they had suffered loss in condition during their long and strenuous trek down to the coast.

The College party attended a reception on Saturday evening given by His Excellency the Governor and Lady Northcote and on Sunday morning some of them visited Plantation Diamond. A departure was made on Sunday afternoon by the *Lady Hawkins* and Trinidad reached on the following afternoon.

The arrangements made were excellent, and thanks are due to the Acting Director and his staff for the way in which they took the trouble to explain the various departmental activities. Hospitality was in the traditional Demerara style and was greatly appreciated.

G. E.

COLLEGE SPORTS.

Athletic Sports Meeting.

A most successful Athletic Sports meeting was held on the College grounds on the afternoon of the 20th March. Athletic sports have not been held at the College since 1926 and it is hoped that in view of the success of this meeting they will, once again, become a regular annual fixture. The events were all very keenly contested and seven new records were established. The results were as follows :—

L. H. Lord and E. D. Weller who both ran exceptionally well tied for the *Victor Ludorum Cup* which was very kindly presented by the Principal. The Inter-Year Relay Cup presented by Mr. Gianetti was won by the First Year Students (Chinloy, Weller, Hernandez, Lord) who won the event (4 × 110 yards) in the record time of 51 1/5 secs. A special prize for throwing the Cricket Ball

Event.	1st.	2nd.	3rd.	Time or Distance.
100 yds.	Lord	Weller	Harris	10 1/5 secs.*
220 yds.	Lord	Weller	Gonzales	23 2/5 secs.*
Quarter Mile	Lord	Weller	Gonzales	59 2/5 secs.
Half Mile	Weller	Posnette	Bond	2 mins. 24 3/5 secs.
One Mile	Bond	ffrench-Mullen	Welch	5 mins. 40 2/5 secs.*
High Jump	Nanton	Harris	Hernandez	5 ft. 2 1/2 ins.*
Long Jump	Delgado	Weller	Stuart	17 ft. 11 ins.
Cricket Ball	Nanton	Henriques	Stuart	100 yds. 1 ft. 0 ins.*
Weight	Nanton	Delgado	Henriques	37 ft. 1 3/4 ins.*

* Record.

was won by W. R. E. Nanton. The Staff *v.* Students Relay which was a very close race ended in a win for the Students. The officials were:—Judges: Sir G. Evans, Professor Wood, Professor Cheesman, Professor Shephard, Mr. Paterson and Dr. Duthie. Time-keepers: Professor Hardy and Mr. McCreary. Clerk of the Course: Mr. Gianetti. Recorders: Messrs. Langdale and Leonard. Starter: Mr. Baker. Megaphone Steward: Mr. Allen.

The success of the meeting was due in a large measure to the enthusiasm of Messrs. Hay, Posnette and McCreary and to Mr. Baker, Hon. Secretary of the Amalgamated Clubs who were responsible for all the arrangements which were excellent. At the end of the meeting Lady Evans presented the prizes to the winners.

* * *

Hockey 1936-37.

The Hockey season was on the whole enjoyable, but unfortunately not a very successful one. The Club entered in the league fixtures this year as there was no competitive hockey being played. In addition fixtures were arranged privately with the Leaseholds and the Prison, the latter being a new club formed by the Staff of the local prison.

The first three fixtures were won by the College with no great effort, but most of the others were lost. The team lost their captain for the latter half of the season and D. H. Welch kindly acted in his place on the field. A Post-graduate *vs.* Diploma Students match was played which resulted in a victory for the post graduates.

The following represented the College:—R. F. Innes, Mr. R. E. D. Baker, Dr. D. W. Duthie, D. L. Foster, D. H. Welch, A. C. Gomez, G. D. Badger, A. F. Posnette Mr. B. de L. Inniss, O. M. Henriques (Capt.). R. T. Hernandez. *Reserve*: M. A. Akenhead.

Professor R. C. Wood and Mr. C. W. R. McCreary very kindly refereed several of the matches.

Tennis 1936-37.

In the final of the College Singles Handicap Tournament Mr. G. G. Gianetti (-30) beat Mr. D. D. Paterson (-½ 30) 7-5, 6-4, 6-3, after a well contested match. Both E. Martin and Mr. C. C. Skeete reached the semi-finals.

OLD STUDENTS' CORNER.

A. R. Melville (1935-36) is in Kenya as Government Entomologist. According to Tom Bell (1935-36) he flew to Nairobi.

* * *

O. S. Millburn (1932-33) is on the staff of the Imperial Economic Committee as Economic Assistant.

* * *

D. F. Stewart (1932-33) who was Inspector of Plant and Produce in the Gold Coast has gone to Uganda as Agricultural Officer.

* * *

H. MacLuskie (1929-30) who was Agricultural Superintendent in British Guiana has joined the Departemnt of Agriculture, Sierra Leone, as Agricultural Officer.

* * *

We offer our congratulations to Mr. and Mrs. A. E. Moss (1931-32) on the birth of a daughter in London on 6th January, 1937.

* * *

E. I. James (1925-26) has been promoted to Senior Agricultural Officer in the Department of Agriculture, Nigeria.

* * *

L. L. de Verteuil (1929-32) has gone to the Gold Coast as Inspector of Plants and Produce.

Printed by the Government Printer.